January 2002 USACHPPM Technical Guide 230

Chemical Exposure Guidelines for Deployed Military Personnel

U.S. Army Center for Health Promotion and Preventive Medicine

PREFACE

In line with various Department of Defense Instructions (DODIs), Headquarters Department of the Army (HQDA) Letter 1-01-1 (2001) *Force Health Protection (FHP): Occupational and Environmental Health (OEH) Threats* establishes responsibilities that direct commanders to use the operational risk management (ORM) process to manage Force Health Protection – Occupational and Environmental Hazards (FHP-OEH) and to minimize total [health and safety] risk to personnel across the broad spectrum of military operations. This includes identifying, documenting, and reporting exposures to OEH hazards (e.g., chemical) that may result in short- or long-term health effects to deployed military personnel.

This document combines and supersedes TG 230A, *Short-Term Chemical Exposure Guidelines for Deployed Military Personnel* (May 1999), and TG 230B, *Draft Long-Term Exposure Guidelines for Deployed Military Personnel* (May 2000). This TG provides the most current military guidance for assessing chemical hazards during deployments in line with existing ORM doctrine.

Additional Information, Updates, and Revisions

Chemical hazard risk assessments for deployments have been performed on a regular basis since 1995 by the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) as well as other service organizations. The USACHPPM approach to characterizing chemical-related risks has evolved over the past several years. Our goal has been to learn through experience and establish a standardized, supportable methodology that will ultimately be applied directly "in the field" by appropriate military medical/health personnel.

USACHPPM has also assisted the Army Medical Department (AMEDD) Center and School in incorporating a session on TG 230 in the basic 6AF5 course for new Army medical and preventive medicine officers. As such, it is reasonable to expect a growing awareness and understanding of this guide and its use. In addition to the basic guidance the USACHPPM is continuing associated efforts to facilitate consistent assessment of chemical hazards. One such effort is to establish chemical-specific summary information called Chemical Hazard Information for Deployments (CHIDs). Each of these sheets will summarize a variety of physical, chemical, toxicological, medical and detection information not available in the TG 230. The USACHPPM is developing CHIDs on a case-by-case basis for chemicals often detected or for which specific information has been requested. Finally, one of our major initiatives during 2002 will be the development of a software program that will guide the user through the TG 230 process, assisting in summarizing data and addressing unique issues associated with various chemical hazards to produce a standardized ORM Deployment Chemical Risk Assessment Summary Report. We are hoping to have this available from our website by 2003.

This TG and its supporting Reference Document (RD 230, USACHPPM 2001) present our current methodology. Due to scientific advances and expanding operational needs, our methods and documents will be updated as necessary. Users should ensure that they have the most up-to-date version of TG 230 and any supporting reference materials and guidance. This document and associated information (to include information regarding past and present deployment support assessments such as for deployment operations in Bosnia, Kosovo, and Kuwait) can be obtained electronically from the following website:

http://chppm-www.apgea.army.mil/desp/pages/samp_doc.htm

Questions, comments, and recommendations can also be forwarded to USACHPPM:

US Army Center for Health Promotion and Preventive Medicine
Deployment Environmental Surveillance Program
ATTN: MCHB-TS-EES
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SECTION 1

INTRODUCTION

1.1 PURPOSE

> Everyday as we respond to the nation's needs, we expose our soldiers to hazards in uncertain and complex environments. We do this with the full knowledge that there are inherent risks associated with any military operation. The nature of our profession will not allow for either complacency or a cavalier acceptance of risk.
>
> —General D.J. Reimer, Chief of Staff Army (DA 1998)

Technical Guide 230 (TG 230) provides military exposure guidelines (MEGs) for chemicals in air, water, and soil for use during deployments. Specific information is provided regarding the type and severity of health effects resulting from exposures to varying chemical concentrations, the primary organs/systems affected, odor /taste threshold information, and additional notes when available. Perhaps more importantly, this TG provides application guidance describing how the MEGs can be used to characterize the level of health and mission risks associated with identified or anticipated exposures to chemicals in the deployment environment in a manner consistent with the existing military Operational Risk Management (ORM) paradigm. The intent is that trained personnel such as preventive medicine officers, environmental staff officers, industrial hygienists, health risk assessors, or other medically trained personnel, can use this guide to consistently characterize risks from chemical exposures by use of a standardized process that is both scientifically supportable and militarily feasible. This TG is not designed for typical garrison operations, as these are covered under existing Department of the Army (DA) occupational health and environmental compliance regulations. However there is limited application in catastrophic continental United States (CONUS) scenarios (i.e., terrorist events). Further details are included in Sections 1.1.2 and 1.4 discussing the intended applications. For the convenience of the reader, Appendix A presents the references used in this TG and Appendix B provides a glossary and list of acronyms.

1.1.1 Key Assumptions and Decisions

Developing this guidance required several up-front risk management decisions that cannot be answered definitively by science. To the extent possible, these reflect existing military policy/ directives, but some issues are not adequately determined by current policy or regulation. The key decisions/assumptions used in the preparation of this document include:

- Whether health effects caused by chemical exposures during a deployment are immediate or delayed (even delayed for several years), the risk of *any* adverse health effect is to be considered in military operations. However, since military ORM focuses on success of the current mission, the guidance presented in this TG is based on the decision that health effects that have immediate impacts and affect personnel functional capabilities are of greater concern than delayed health effects (e.g., increased risk of cancer).

- The military population, for which these guidelines are developed, is assumed to be "healthy and fit" and often believed to be less susceptible to the adverse health effects caused by chemical exposures than the general (civilian) population. However, this assumption has been debated and an assessment of susceptibility traits amongst the military population concluded that for many health effects the military population is of equivalent variability as the general population (see section 2.4). There are known and unknown subpopulations within the deployed military population that may be uniquely susceptible to effects caused by certain chemicals. In some cases where adequate information was available, the MEGs accommodate a susceptible group within the military population (e.g., asthmatics, who are included in deployment operations). Although pregnant women are not considered deployable, there are potential scenarios where a woman may be deployed without realizing her pregnant status. Since developmental effects caused by chemical exposures are often associated with first trimester exposures, and since the fetus is considered a *third party* involuntarily being put at risk, legal and ethical recommendations have resulted in these guidelines to be protective against developmental effects where such data was available. As a result, several MEGs are the same as would be applied to a civilian population. However, the MEGs have been screened to ensure that they are not based on health effects that are clearly not associated with deployed military personnel (i.e. they are not designed to protect people that would never be deployed such as children or the elderly).

- Current scientific methods for deriving human health guidelines focus on estimating human threshold concentrations by using toxicological data along with safety factors to account for various data gaps and uncertainties. The resulting MEGs in this TG represent conservative *population thresholds* for different types of health effects. This provides the user with an idea of when the specified effect may begin to be noticed in a small percentage of the exposed persons. It does *not* represent levels at which the majority, median, or 50% of personnel will demonstrate such effects as the selected scientific models do not provide this information.

1.1.2 Scope

This version of TG 230 is a combined and updated version of TG 230A and TG 230B (see Preface). The associated Reference Document (RD 230) has also been completed to support the material herein. Specific technical material has been limited in this TG to facilitate field use. RD 230 provides the technical information that support the derivation of the MEG values and other information contained herein.

This TG does not address biological or nuclear/radiation hazards. Its focus is on chemical hazards – both chemical warfare agents (CWAs) as well as toxic industrial chemicals (TICs). However, there are limitations in this TG regarding chemical hazards:

- Not every chemical is listed (see section 1.4.1) since many chemicals have limited toxicity information available. TG 230 has focused on chemicals with readily available information or which were otherwise identified as key hazards of concern. Future amendments to TG 230 will include both updated MEGs as well as the addition of chemicals.

- Other aspects critical to addressing occupational and environmental health (OEH) chemical hazards include guidance on sampling contaminated media, control methods, and medical treatment. While these topics are beyond the scope of this TG, additional guidance in these areas is currently being developed by USACHPPM in the form of Chemical Hazard

Information for Deployments (CHIDs) (see Preface) as well as other guidance (see the back cover).

✍✍The purpose of the MEGs is to provide protection to our personnel from chemical exposures during deployments. The MEGs are not designed for environmental compliance purposes and should not be used as environmental compliance/preservation/remediation goals in CONUS or outside the continental United States (OCONUS).

1.2 BACKGROUND

> Risk Management is not an add-on feature to the decision-making process but rather a fully integrated element of planning and executing operations… Risk management helps us preserve combat power and retain the flexibility for bold decisive action. Proper risk management is a combat multiplier that we can ill afford to squander.
>
> —General D.J. Reimer, 1995 (DA 1998)

1.2.1 Health and Operational Hazards

The deployed military population is subject to a variety of operation-related hazards. These hazards include climate conditions (e.g., excessive heat, cold and noise), infectious diseases, physical threats (including those associated with accidents, explosions, and certain forms of ionizing radiation), chemical and biological warfare agents, and a large number of chemical contaminants in air, water, food, and soil. Forces might be exposed to these hazards intermittently, continuously, or simultaneously. Exposures to chemicals during deployments and other operations are inevitable. In some situations chemicals may be present for only a short time, but at high enough levels that exposures could immediately impact individual health or even degrade the mission. In other situations, continuous but less extreme levels of chemicals in the environment could put military personnel at increased risk of delayed, permanent health problems.

1.2.2 Health Risk Management Policies and Procedures

The military, scientific, and political communities have recently acknowledged the need to identify and consider (as identifiable military "threats") all toxic chemicals or radiological hazards that pose delayed, chronic health risks to military personnel (IOM 1999, NRC 1999, DOD 1999, DODI 6055.1, and NSTC/PRD 5). Military leaders and their staff elements are now responsible for monitoring, assessing, and minimizing OEH hazards to ensure force health protection. A listing of policies, procedures, and guiding principles for the management of such hazards are listed in RD 230.

Deployment scenarios can involve a range of operations from sustaining peace and stability to direct combat. While the hazards may be of a different nature during these operations, the hazard management process is the same. This process requires the identification of hazards, a standardized categorization of the risks, and a decision process that appropriately balances these risks to minimize adverse impacts on the mission and personnel. Field Manual (FM) 100-14, *Risk Management* and FM-3-100.12, *Risk Management: Multiservice Tactics, Techniques, and Procedures* provide the ORM doctrine that defines this process. Making decisions to accept, minimize, or altogether prevent OEH hazards must be made in conjunction with assessments of other operational hazards that put the commander's mission and personnel at risk.

It is DOD and Army policy to address the health and mission risks associated with chemical exposures within the overall ORM process (DODI 6055.1 and HQDA Letter 1-01-1). Specifically, appropriate consideration of OEH chemical hazards are a part of Force Health Protection (FHP), and proper assessment and surveillance should be used to minimize both immediate health and mission impacts, as

well as any potential delayed health effects that adversely effect the long-term health of service men and women. The objective is to minimize overall health risks while achieving successful mission completion. This will always be a balance. War-time operations will inevitably yield higher acceptance of casualties, while peacekeeping missions will require greater need to minimize non-severe health effects associated with what has been referred to as "low-level" exposures. Low-level exposures are those that may not significantly impact the current mission or result in any function-impairing effects, but which constitute an exposure that could have a health effect. Further discussion on different levels of health effects and associated mission impacts are discussed in Section 3 and presented in Table 3-1.

TG 248, *Guide for Deployed Military Personnel on Health Risk Management*, (USACHPPM 2001) provides a general framework for addressing OEH hazards (i.e., chemical, radiological, biological, entomological, endemic disease) in a way that implements the established ORM process, as defined by FM 100-14. This revised TG 230 was developed following the framework used in TG 248. Appropriate application of ORM and this TG will allow appropriate consideration be given to chemical hazards. The use of MEGs within the TG 248 ORM process is presented in Section 3.

1.3 AUDIENCE

> Staff members continuously look for hazards associated with their area of expertise. They then recommend controls to reduce those risks…. Leaders, staff and soldiers become the assessors for ever-changing hazards such as those associated with the environment (weather, visibility, contaminated air, soil, water), equipment readiness, unit experience, and fatigue. Leaders and staff should advise the chain of command on risks and risk reduction methods.
>
> —FM 100-14, Risk Management

TG 230 is designed to assist trained preventive medicine/medical personnel in the evaluation of chemical exposure data in order to minimize health and mission risks during deployments. These trained personnel are to use the TG as an objective base from which to make educated determinations. It is not intended for use by untrained personnel or as a substitute for having trained preventive medicine personnel onsite or in theater. Users should have a basic understanding of the underlying toxicological/health basis for these guidelines. They should be familiar with basic methods of exposure assessment of chemicals in the environment. Finally, it is necessary that the user appreciate the uncertainties associated with sampling and with the assumptions used for estimating representative exposure levels. Military health services personnel will need to use professional judgment when applying the standardized information in this guide; however, they will be more adequately prepared to determine the severity of health hazards within a framework that is consistent with other military risk management decisions.

1.4 APPLICATION AND LIMITATIONS OF USE

> First reckon, then risk.
>
> —Field Marshal Helmuth von Moltke, FM 100-14, Risk Management (DA 1998)

> Risk Management is the recognition that decision-making occurs under conditions of uncertainty… —FM 100-14, Risk Management (DA 1998)

In general, this TG should be used to characterize health and medical threats and the risks they pose to personnel and the mission. The user should compare the guidelines with field sampling data or other (e.g., modeled) exposure data information. The interpretation of these comparisons will require professional judgment. Due to the uncertainties that are inherent in the toxicological data, as well as the variations in human response to chemical exposure and the exposure estimates that go into establishing health-based guidelines, users should not use the MEGs as strict, bright-lines (i.e., go/no-go standards) for decision making unless so noted (e.g., water MEGs based on TB MED 577). Instead, the TG and its range of MEGs provide a set of criteria that are to be used to identify and rank OEH risks from chemical exposures in a deployment setting. The range of concentration levels and exposure durations represented for each chemical are designed to give the user an idea of the overall toxicity and types of health effects associated with certain exposure scenarios. MEGs range from high levels that represent a "threshold" for fatality to levels that could be present continuously for short or long-term periods without resulting in any significant symptoms.

1.4.1 Use in Different Types of Deployment Scenarios

For certain types of deployment operations (such as direct combat), it is anticipated that such guidelines will be of limited importance to the overall ORM decision-making process. That is, "physical" hazards such as armed adversaries will present much greater risks and, therefore, be of greater priority. For other scenarios, such as long-term humanitarian deployment operations, the considerations of overall long-term personnel health may play a more critical role in risk management decisions. Accordingly, these guidelines are to be used at the discretion of the commander. As stated in the HQDA Letter 1-01-1 (2001) *Force Health Protection (FHP): Occupational and Environmental Health (OEH) Threats*:

> "…commanders [need to be] aware of and consider risks created by OEH exposures (both long-term and short-term) during all phases of military activities…[and]…reduce OEH exposures to as low as practicable to minimize short- and long-term health effects in personnel within the context of the full spectrum of health and safety risks confronting the deployed personnel."

1.4.2 Other Technical Guidance Pertaining to Chemical Hazards

To the extent possible, a wide variety of occupational, environmental, and military standards have been considered and incorporated into the development of these guidelines. There is a substantial amount of technical information on various chemicals that can be obtained from other sources (hardcopy or electronically such as through the internet). To the extent that personnel have the resources, accessibility, and time to review additional information, this is encouraged as it will likely increase overall confidence in the assessment and characterization of risk. However, it is anticipated that there will be situations where there are inconsistencies in information or guideline levels. To the extent possible, RD 230 delineates in detail the basis for the MEGs and in many cases describes reasons for conflicts with other standards. Where such explanations are not available, the user must use professional judgment or contact USACHPPM for consultation. When assessing industrial-type operations during deployments, where the soldiers' activities involve typical 8-hour workday situations (e.g., motor pool maintenance), existing industrial hygiene standards may be more appropriate than MEGs.

1.4.3 Use with Caution: Scientific Uncertainties

Uncertainties involved in the development of these guidelines are principally those related to exposure parameters and toxicological data. Uncertainties in the toxicological data may result from data gaps, insufficient quality or quantity of data, and/or lack of human data. Exposure assumptions used in developing these guidelines include inhalation and ingestion rates, body weights, and frequency and duration of exposure. These assumptions may or may not represent those in actual deployment scenarios.

Furthermore, the environmental levels estimated through sampling are often not likely to remain constant. The user must consider these uncertainties when making risk management decisions or recommendations.

Use of this TG should not be construed as a "definitive quantification of health outcomes." In most deployment scenarios, it will be difficult to make definitive statements as to the absolute degree of risk/type of health effect(s) caused by environmental contaminants. Even statements regarding whether a risk is present or not must be carefully stated to ensure that the uncertainty inherent to any risk assessment is accurately considered and weighed.

In addition to communicating a level of risk associated with a chemical hazard, a user should be prepared to describe the degree of confidence in his/her assessment (such as high, moderate, or low confidence). An estimate of a "high" risk that has low confidence (i.e., uncertainty is high) may significantly influence Command decisions, especially if there are other high risks for which there is greater levels of certainty. Guidance for determining confidence levels is provided in Section 3.3.

Due to limitations in toxicity data, the nature of chemical exposures and human variability, OEH chemical risk assessments should almost never be ranked with high confidence. For the most part, the MEGs are conservatively designed so that confidence in estimated *Low Risks* will tend to be greater than those estimated to be *High Risk*.

1.4.4 Chemical Not Listed in these Guidelines

Though the list of chemicals included in this TG is quite broad, there are occasions where identified chemicals will not have a specified guideline. In general, this may be because there is limited toxicity information available for the chemical. Occasionally, there may be a short-term guideline but no long-term guideline for a chemical. In these cases, it is likely that the chemical poses primarily an acute (short-term) hazard at higher concentrations but at lower concentrations there are no documented effects, even after continued long-term exposures. On the other hand, some chemicals may not pose a health risk unless the exposure is constant and repeated over a long-term exposure. In this case, there may not be any short-term MEGs.

In any situation where there is information lacking on a chemical, the user has a few options: (1) contact USACHPPM to do research and characterize severity and risk; (2) establish an overall risk estimate based on other chemicals and information in this TG and document the uncertainty (i.e., reduced confidence) in the risk estimate by not including a chemical assessment of the chemical(s) with no MEGs; or (3) research the chemical (e.g., literature or internet resources) and establish a surrogate guideline.

Key reference sites for looking up additional chemical information are prioritized below. When using values/data from these sites the user should attempt to be consistent with the MEG derivations/guidelines presented in RD 230.

- http://toxnet.nlm.nih.gov/
- http://www.cdc.gov/niosh/npg/npg.html
- http://www.epa.gov/region09/waste/sfund/prg/index.htm

1.4.4.1 "Non-Hazards". Some chemical data received from routine laboratory analyses will include certain chemicals/ constituents/compounds that can be readily identified as "non-hazards". These are primarily identified in soil or water analysis and include essential nutrients, minerals, and related compounds. They are found commonly in nature and are considered, at least at some level, beneficial or even necessary to the proper functioning of the human body.

Soil: If identified in laboratory results, the following are examples of constituents that can generally be considered as non-hazards and do not need to be factored into a health risk assessment. These constituents are generally only toxic when ingested in large amounts at high concentrations, which is not realistically feasible from soil ingestion at typical environmental concentrations. For these reasons, many of these constituents lack Federal guidance as well.

TABLE 1-1. TYPICAL NON-HAZARDOUS CONSTITUENTS DETECTED IN SOIL

Aluminum	Barium	Magnesium	Potassium	Sodium
Calcium	Iron	Manganese	Selenium	

Drinking Water: Drinking water analysis also often includes constituents that may not cause adverse health effects, but which may aesthetically (e.g., color, taste, odor) make the water less palatable. This could lead to reduced consumption that could in turn result in indirect health effects from dehydration (Case Study 4 in Appendix F provides an example scenario). In addition, these criteria may be a useful source of information when evaluating water treatment system capabilities. While there are guidelines and standards (per TB MED 577) to ensure that aesthetic standards are met – it is useful to note that these guidelines/criteria are not based on direct toxic health effects. Tables 1-2 and 1-3 summarize various aesthetic factors considered in assessing drinking water.

TABLES 1-2 AND 1-3. AESTHETIC FACTORS IN ASSESSING DRINKING WATER

Table 1-2. Physical Properties	**Maximum level 5-15L/day (TB Med 577)**	
	<7 days	>7 days
Color (color unit)	50	15
Odor (TON)	3	3
pH	5-9	5-9
TDS (mg/L)	1000	1000
Turbidity (NTU)	1	1

Table 1-3. Chemical Properties	**Recommended maximum level (U.S. EPA*)**
Aluminum	0.05 – 0.2 mg/L
Fluoride	2 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Silver	0.1 mg/L
Sulfate	250 mg/L

* U.S. EPA public drinking water criteria are recommendations only.

SECTION 2

MILITARY EXPOSURE GUIDELINES

2.1 WHAT ARE MEGs?

MEGs are concentrations for chemicals in air, water, and soil that can be used to assist in assessing the significance of field exposures to OEH chemical hazards during deployments. TG 230 MEGs are designed to address a variety of scenarios such as a single catastrophic release of large amounts of a chemical, temporary exposure conditions lasting hours to days, or for continuous ambient environmental conditions such as regional pollution, use of a contaminated water supply, or persistent soil contamination where there is regular contact. For each environmental media there are slightly different exposure scenarios of concern.

Specifically, a MEG is a chemical concentration which represents an estimate of the level above which certain types of health effects may begin to occur in individuals within the exposed population after a continuous, single exposure of specified duration. The severity of the health effects and percentage of the exposed population demonstrating health effects will increase as concentrations increase above the MEG, but the rate is chemical-specific, and therefore cannot be represented by the MEGs themselves. The MEGs are not designed for determining casualty estimates but are instead are preventive measures guidelines.

Since existing toxicological databases were utilized, the quality and extensiveness of toxicological information underlying these guidelines is comparable, and as variable, as that used by Federal agencies for worker and civilian applications. For specific details on the various approaches and methods used to develop the guideline values, refer to RD 230.

2.1.1 Air-MEGs: Inhalation of Chemicals

Table 2-1 defines the types of Air-MEGs and the meaning behind exceedences of the various air guidelines. Air-MEGs are presented in Appendix C.

In deployment situations, the most prominent and likely exposure pathway for exposure to chemicals is through the inhalation of contaminated air. As contaminants in air are difficult to avoid or control and may produce immediate and severe health effects, a variety of Air-MEGs were developed. Some of these levels represent severe conditions that are likely to have real-time, direct impacts on personnel performance and mission accomplishment/success. For selected CWAs, Air-MEGs are provided for temporary and short-term exposure scenarios of 10 minutes, 1 hour, 8 hours, and 24 hours (Table C-1). For other airborne chemicals, Air-MEGs for short-term exposure scenarios of 1 hour, 8 hours, and 14 days are provided (Table C-2). Air-MEGs are also provided for 1-year (deployment-length), continuous exposures (Table C-3). Guidelines for priority pollutants are provided in Table C-4.

TABLE 2-1. DEFINITIONS OF HEALTH EFFECTS ASSOCIATED WITH AIR-MEGS

EXPOSURE DURATION		HEALTH EFFECTS AND PERFORMANCE DEGRADATION *
SHORT-TERM	1-hour	The airborne concentration above which continuous exposure for 1 hour could begin to produce life-threatening or lethal effects in a small portion of individuals. Increasing concentrations and/or duration of exposure will increase incidence of lethality and severity of non-lethal severe effects.
	1-hour	The airborne concentration above which continuous exposure for 1 hour could begin to produce irreversible, permanent, or serious health effects that may result in performance degradation and incapacitate in a small portion of individuals. Increasing concentrations and/or duration of exposure will increase incidence and severity of effects.
	1-hour	The airborne concentration above which continuous exposure for 1 hour could begin to produce mild, non-disabling, transient, reversible effects, if any. Such effects should not impair performance. Increasing concentration and/or duration could result in performance degradation, especially for tasks requiring specific mental/visual acuity or physical dexterity/strength.
	8-hour and 24-hour **	The airborne concentration above which continuous exposure for 8 or 24 hours could begin to produce mild, non-disabling, transient, reversible effects, if any. Such effects should not impair performance. Increasing concentration and/or duration could result in performance degradation, especially for tasks requiring specific mental/visual acuity or physical dexterity/strength.
	14-day	The airborne concentration for a continuous exposure for up to 14 days (24 hours/day) that should not impair performance and is considered protective against significant, non-cancer effects. Increasing concentration and/or duration could result in performance degradation or increase the potential for inducing delayed/permanent disease (e.g., kidney disease or cancer).
LONG-TERM	1 year	The airborne concentration for a continuous exposure up to 1 year (365 days, 24 hours/day) that is considered protective against health effects including chronic disease and increased risk to cancer (i.e., cancer risk greater than 1×10^{-4}). No performance degradation or long-term health consequences are expected with exposure at or below this level. Increasing concentration and/or duration could increase the potential for delayed/permanent disease (e.g., kidney disease or cancer).

* Sensitive individuals may be predisposed to toxic effects and, therefore, maybe more susceptible. If available scientific evidence regarding such subpopulations exists for a particular chemical, then this information is provided in the guideline tables.

** For military unique chemicals warfare agents (i.e., GA, GB, GD, GF, VX, and HD), a 24-hour MEG has been derived instead of a 14-day MEG because of the likelihood for CWA exposures to extend beyond a 24-hour period is extremely small. The 24-hour CWA MEGs are described in detail in Table C-1. The definition of effects associated with these values is the same as the 8-hour guidelines.

2.1.2 Water-MEGs: Chemicals Ingested in Potable Water

Table 2-2 defines the types of Water-MEGs and the meaning behind their exceedence. Water-MEGs are presented in Appendix D – Table D-1 for short-term exposure scenarios of 5 days and 2 weeks and Table D-2 for 1-year (deployment-length) continuous exposures.

Potable water implies various uses; however, these guidelines reflect the specific exposure pathway of direct consumption of a water source. Applying such guidelines to make decisions regarding bathing, teeth brushing, dishwashing, or other non-potable water applications are over-conservative applications, but at this time no other guidelines have been derived for these specific scenarios.

Water-MEGs are based on specific exposure conditions that are described by daily rates of water consumption that have been designated as typical standards for military deployment operations: 5 liters (L)/day for moderate climates and 15 L/day in dry/arid climates. These rates are extremely high in comparison to typical general population drinking /consumption rates (e.g., 2L/day) but these rates have been validated and established in Army doctrine (TB MED 577). The Water-MEGs are designed to indicate "thresholds" for minimal to no adverse health effects. The health effects at these levels do not generally represent observable degradation in personnel performance. However, the more chemical concentrations in a water source exceed a guideline level or the duration of exposure, the more likely that a greater portion of those exposed will develop symptoms of exposure. When available, information regarding levels that produce severe or lethal effects is also provided in the Appendix D tables.

TABLE 2-2. DEFINITIONS OF HEALTH EFFECTS ASSOCIATED WITH WATER-MEGS

EXPOSURE DURATION		HEALTH EFFECT	HEALTH EFFECTS AND PERFORMANCE DEGRADATION *
SHORT-TERM	5 days 5 or 15 L/day	MINIMAL TO NONSIGNIFICANT	The drinking water concentration for a continuous daily consumption of either 5 L/day or 15 L/day for up to 5 days that should not impair performance and is considered protective against significant non-cancer effects. Increasing concentration and/or duration could result in performance degradation, need for medical intervention, or increase the potential for delayed/permanent disease (e.g., kidney disease or cancer).
	14 days 5 or 15 L/day	MINIMAL TO NONSIGNIFICANT	The drinking water concentration for a continuous daily consumption of either 5 L/day or 15 L/day for up 14 days that should not impair performance and is considered protective against significant non-cancer effects. Increasing concentration and/or duration could result in performance degradation, need for medical intervention, or increase the potential for delayed/permanent disease (e.g., kidney disease or cancer).
LONG-TERM	1 year 5 or 15 L/day	NONSIGNIFICANT TO NONE	The drinking water concentration for a continuous daily consumption of either 5 L/day or 15 L/day for up to 1 year that should not impair performance and is considered protective against health effects including chronic disease and increased risk to cancer (i.e., cancer risk greater than 1×10^{-4}). Increasing concentration and/or duration could increase the potential for delayed/permanent disease (e.g., kidney disease or cancer).

* Sensitive individuals may be predisposed to toxic effects and, therefore, maybe more susceptible. If available scientific evidence regarding such subpopulations exists for a particular chemical, then this information is provided in the guideline tables.

2.1.3 Soil-MEGs: Daily Exposure through Contact, Ingestion, and Inhalation

Table 2-3 defines the Soil-MEGs and the meaning behind their exceedences. Soil-MEGs for 1-year (deployment-length) continuous exposures are presented in Appendix E. Soil-MEGs for short-term exposure scenarios were not developed for the following reasons. Typically, unless obvious odors, dead or discolored vegetation, or free chemical product is observed, soil contamination is not anticipated to be an immediate or severe hazard. If such conditions are observed, such areas that may contain contaminated soils are usually relatively easy to avoid.

Soil-MEG values are based on specific exposure assumptions that are described by daily rates of activity to include breathing rates, incidental soil ingestion rates, and dermal contact rates that are expected to be typical for military deployment operations. These soil guidelines are designed to indicate "thresholds" for no adverse health effects. As the parameters of the MEG are exceeded (e.g., chemical concentrations exceed soil MEGs, or exposure durations increase), it becomes more likely that greater portions of individuals in the exposed population will experience adverse health outcomes.

TABLE 2-3. DEFINITIONS OF HEALTH EFFECTS ASSOCIATED WITH SOIL-MEGS

EXPOSURE DURATION		HEALTH EFFECT	HEALTH EFFECTS AND PERFORMANCE DEGRADATION
LONG-TERM	1 year	NONSIGNIFICANT TO NONE	The soil concentration for continuous, daily exposure (from ingestion, dermal absorption, and inhalation) for up to 1 year (365 days) that should not impair performance and is considered protective against any health effects including chronic disease and increased risk to cancer (i.e., cancer risk greater than 1×10^{-4}). Increasing concentration and/or duration could increase the potential for delayed/permanent disease (e.g., kidney disease or cancer).

* Sensitive individuals may be predisposed to toxic effects and, therefore, maybe more susceptible. If available scientific evidence regarding such subpopulations exists for a particular chemical, then this information is provided in the guideline tables.

2.2 CHEMICAL HAZARDS WITH UNIQUE CONCERNS

2.2.1 Chemicals Warfare Agents (CWA)

The primary CWAs addressed by this TG include the nerve agents (GA, GB, GD, GF and VX) and the vesicants or blister agents (Sulfur Mustard (HD) and Lewisite). Currently, military risk management decisions regarding CWAs are somewhat unique in comparison to that of other TICs addressed by this TG. In part, this is because various Army, DoD and Joint Staff policy and doctrinal documents establish procedures and standards to address potential military exposure to CWA. Most of the existing operational Nuclear, Biological, and Chemical (NBC) policies and procedures focus on the wartime scenario. (See the back cover for a list of a few key NBC references.) Much of the responsibility is assigned to the Chemical Corps or designated NBC personnel. Much of the existing doctrine and equipment has focused on "presence-absence" identification as opposed to estimation of degree of risk. Medical responsibilities for NBC have historically been limited to casualty management with preventive medicine aspects focused on antidote development and administration. Today, with varying types of deployments and increased attention to health effects that may be more subtle and/or long lasting, the policies, doctrine, and even equipment (such as detection and monitoring devices) are undergoing evaluation and change. Requirements (HQDA Letter 1-01-1, 2001) to address mild or delayed health

effects in operational risk management – including scenarios involving potential residual or low-level CWA concentrations require more information than what has been previously incorporated into doctrine. Most scenarios involving CWA will still require Chemical/NBC personnel involvement. Follow-up and/or joint evaluation by medical/preventive medicine personnel is necessary to ensure that the potential for residual CWA contamination is appropriately considered and documented.

2.2.1.1 Air-MEGs

The Air-MEGs for CWAs (Table C-1) are based on the same technical and toxicological models that the other chemical Air-MEGs are based on with the exception of Lewisite, which has a limited toxicity database and therefore has guidelines derived largely from a conservative baseline detection limit. Therefore, the MEGs can be used to demonstrate relative potency or toxicity of the chemicals. The Air-MEGs for CWA are provided for 1-hour, 8-hour, and 24-hour exposure durations. Air-MEGs for the 14-day and 1-year exposure durations were not developed because CWAs are generally not persistent in the air for longer than 24 hours.

2.2.1.2 Water-MEGs

Drinking Water-MEGs are extracted directly from the doctrinal requirements of TB MED 577. These TG Water-MEGs are, therefore, "standards" which must not be exceeded. As with the air exposure pathway, extended exposure to small amounts of CWA in a drinking water source is not a plausible scenario (due to physical/chemical characteristics of the agent as well as the military requirements that would prohibit extended use of such a water source), therefore, only short-term CWA Water-MEGs are provided.

2.2.1.3 Soil-MEGs

Despite the general non-persistent nature of CWA in air and even water, binding to soil or other solid media can potentially extend the presence of CWA in a deployment setting. This is particularly true for the agents HD and VX. Cold temperatures and dry climates will tend to extend the persistence of these chemicals; on the other hand, rain and heat are natural mechanisms of degradation.

Decisions concerning reentry and post-decontamination scenarios (i.e., after air monitoring has cleared the immediate airborne hazard concern) may need to be validated through specific analysis of soil or other solid material. Soil-MEGs have been conservatively developed using the same model used to derive 1-year Soil-MEGs for other TICs in this TG.

2.2.2 Ambient Air Quality: Priority Pollutants and Particulates

The USEPA has identified seven "criteria pollutants" or "priority pollutants" as indicators of air quality and has established for each of them National Ambient Air Quality Standards (NAAQS) reflecting maximum concentrations above which adverse effects on human health may occur. The criteria pollutants are ozone (O_3), particulates [particulate matter (PM_{10}) and ($PM_{2.5}$)], carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and lead (Pb). The sources of these criteria pollutants include factories, power plants, incinerators, automobiles, construction activity, fires and windblown dusts.

As indicators of overall levels of airborne pollution, these pollutants are often of particular focus during deployment environmental surveillance and monitoring efforts. In recent environmental surveillance programs in Bosnia, Kosovo, and Kuwait, levels of these criteria pollutants have exceeded USEPA NAAQS. Ongoing investigations suggest that at high enough levels, these pollutants may be associated with increases in military sick call visits for upper respiratory illnesses. Though delayed or permanent health effects associated with yearlong exposures to these pollutants have yet to be confirmed, there are indications suggesting potential for development or exacerbation of illnesses such as asthma, chronic bronchitis, and theoretically, even cancer. Part of the difficulty in ascertaining the specific association of

a priority pollutant with a specific health effect is the confounding nature of pollution – in which multiple chemicals form unique mixtures in different environments. In general, exceeding guidelines for more than one priority pollutant can be assumed to be of greater health effect than if there was just a single pollutant, but the degree to which one pollutant may modify the effect of another is not well established.

In deployment assessment, sampling efforts during operations should monitor priority pollutants to identify potential adverse health effects to military personnel and to ascertain whether actions are warranted to minimize impacts. For example, pollutant levels might warrant minimizing strenuous outdoor activity at peak hours when pollutants are at their highest concentrations.

Specific short-term Air-MEGs are provided in TG 230 for carbon monoxide, sulfur dioxide, and nitrogen dioxide (see Appendix C, Table C-2). Long-term Air-MEGs have been established for pollutants included in the NAAQS that are consistent with the intent of other Air-MEGs derived for TG 230, which are protective of the military population for 24 hours per day, up to 1 full year (see Appendix C, Table C-3). Additional information and guidance specific to these criteria pollutants is presented in Appendix C, Table C-4.

2.3 POPULATION ASSUMPTIONS

The MEGs are based on the assumption that deployed military populations consist of relatively healthy and fit male and non-pregnant female adults. Deployed military personnel are assumed to be 18 to 55 years of age, with an average weight of approximately 70 kilograms (kg) (i.e., approximately 154 pounds). While a common assumption is that such individuals will have no predisposing physical or mental factors that could exacerbate exposure to environmental chemicals, such an assumption does not appear to be entirely supported through scientific evidence. While there are basic health and fitness requirements that must be met and maintained by military personnel, an assessment of the factors that can lead to chemical specific susceptibilities suggests that many of the primary factors exist for the deployed military population (which includes active duty, reserve, and National guard personnel) (See Section 1.4.4 and Appendix F of the RD 230 for additional discussion). Predisposing factors such as age (>40 years), illness (e.g., asthma), physical and emotional stressors, life-style choices (e.g., smoking or alcohol use), or unique genetic traits may alter susceptibility to a toxicant. These factors are common to both the general population and the deployed military population as well. So, while the MEGs are not specifically designed to address or protect individuals with hypersensitive or critical health conditions, some sensitive sub-populations (identifiable to include genetic subgroups, asthmatics, pregnant females) were factored into these guidelines.

Where intelligence estimates for an area of operation (AO) indicated hazards to known sensitive subpopulations, medical planners may consider establishing medical qualifications for deploying forces to prevent these subpopulations from deploying to the AO.

2.4 DIFFERENT MEGs REFLECT DIFFERENT EFFECTS

2.4.1 Meaning of MEG Exceedences and Predicted Incidence of Symptoms

To the extent possible, MEG values were developed in a manner to attempt to consistently represent designated "thresholds" of differing toxicological severity. However, since the quantity and quality of scientific data upon which the guidelines are based varies substantially amongst the chemicals, the accuracy with which the guidelines represent severity "thresholds" varies. In cases where data for a chemical was extremely limited, a margin of safety has been built into the derived guideline value. In some cases, exposures greater than the MEG can induce immediate adverse health effects that may impact upon the ability of personnel to accomplish their mission. In other cases, exposures greater than the MEG

simply indicate that there is an increased likelihood that a health problem could arise either during or after the deployment is completed. The degree and duration of health effects experienced will depend on: (1) the sensitivity and characteristics of the individual exposed; (2) the duration and frequency of exposures; (3) the concentration of the substance; (4) the rate at which the individual takes in the substance (such as breathing rate or water consumption rate); and (5) the levels of other substances present and their interaction.

In general, environmental concentrations equal to, or slightly greater than, the specified MEG, are expected to result in the specified type and degree of health effect in none to a small portion of individuals in the exposed military population. In some cases, however, the MEG represents a purely "protective" level where health effects should not be observed at all.

Though the MEGs are based on generally conservative interpretations of toxicological data, there are variations among the chemicals in the degree of conservatism. In addition, these MEGs are designed for assessing a single exposure scenario, and do not consider the impacts of multiple deployments with similar or variable chemicals exposures or the inevitable exposures that occur pre- and post-deployment during CONUS-based activities and/or personal time (e.g., related to hobbies or home activities).

2.4.2 Acute and Systemic, Non-Cancer Health Effects

For non-carcinogens, it is assumed that there is a threshold dose, which defines the minimal amount of a chemical necessary to cause a specific adverse health effect or group of effects. Below the threshold dose, a chemical compound is not expected to cause any biologically adverse change. The MEG values for non-carcinogens represent the best estimate of what the average human threshold dose would be under the specific exposure conditions described. Above these concentrations, it is possible that a variety of adverse symptoms of exposure may occur.

The types of health effects and toxicological endpoints associated with exceeding a particular chemical guideline are described in the MEG tables in Appendices C, D, and E. Because toxicological data are often limited, some potential health effects might not be identified. Similarly, there are uncertainties with ascertaining whether any, some, or all of the effects may actually occur. Due to human variability, it is also very difficult to quantify the percentage of exposed individuals that may be impacted. Therefore, trained personnel should interpret with caution any exceedences of a specific MEG. Understanding the *types* of effects and ascertaining whether short-term guidelines are exceeded is very important in determining the severity of the hazard. Also, noting the types of organs/systems that a chemical may effect is particularly important when there are multiple chemicals present and when some have the same types of effects. Tables 2-4-1 and 2-4-2 present the target organ and target systems upon which chemicals may have adverse impact. These groups are also notated along with each guideline in the MEG tables.

TABLE 2-4-1. TARGET ORGANS

TARGET ORGANS
Eyes
Skin
Blood
Bladder
Brain
Heart
Pancreas
Adrenal Glands
Lungs
Liver
Kidneys
Spleen
Thyroid
Bone
Fetus

TABLE 2-4-2. TARGET SYSTEMS

TARGET SYSTEMS
CNS – Central Nervous System
PNS – Peripheral Nervous System
GI tract – Gastrointestinal Tract
RS – Respiratory System
LRS – Lower Respiratory System
URS – Upper Respiratory System
CVS – Cardiovascular System
ChE Inh – Cholinesterase Inhibitor
UT – Urogenital Tract
CRC – Circulatory System
IMM – Immune System
REPR – Reproductive System
HEM – Hemopoietic System
ENDO – Endocrine System
LYMP – Lymphatic System

2.4.3 Cancer

Chemicals that are identified as cancer-causing (i.e., carcinogenic) can also cause local and/or other systemic health conditions. In such cases, both health effects were addressed for the selection of most MEGs. With the exception of severe effect 1-hour Air-MEGs, the majority of the MEGs are protective against local, systemic, and as well as significant excess cancer risk. The significance of cancer risk is unique from other toxic effects in that it is a "non-threshold" effect and therefore exposure at any level may be considered to increase the risk of cancer development. To address this in setting chemical exposure levels, Federal organizations such as the USEPA and Occupational Safety and Health Administration (OSHA) have established "acceptable" excess cancer risk levels. For purposes of TG 230, MEGs represent levels that are protective of excess cancer risks greater than 1×10^{-4}. A cancer risk of 1×10^{-4} means that 1 out of 10,000 equally exposed individuals would be expected to develop cancer as a result of the evaluated exposure. This is within the range of acceptable risk noted by other federal agencies and has previously been indicated an acceptable risk level for DoD (NRC, 1986b). Further discussion is provided in the RD 230, Section 3.1.5.

Uncertainty must be considered when characterizing the risk contributed by a chemical carcinogen. This includes consideration of the certainty with which the scientific community believes it to be a human carcinogen. Weight-of-Evidence (WOE) classifications (Table 2-5) are provided to characterize the degree of certainty with which the USEPA considers the chemical to, in fact, be a human carcinogen. These classifications should be incorporated into the overall risk characterization and confidence estimation process (for example, a chemical that is considered a "C" carcinogen may be considered to pose less risk than one classified as an "A").

TABLE 2-5. CHEMICAL CARCINOGENICITY CLASSIFICATION CODES *

CLASSIFICATION	DESCRIPTION
Class A: Human carcinogen	Sufficient evidence in epidemiological studies to support causal association between exposure and cancer.
Class B: Probable human carcinogen	Limited evidence in epidemiological studies (Group B1) and/or sufficient evidence from animal studies (Group B2).
Class C: Possible human carcinogen	Limited evidence from animal studies and inadequate or no data in humans.
Class D: Not classifiable	Inadequate or no human and animal evidence of carcinogenicity.
Class E: No evidence of carcinogenicity for humans	No evidence of carcinogenicity in at least two adequate animal tests in different species or in adequate epidemiological and animal studies.

* While technically only group "E" chemicals may be firmly stated to be "non-carcinogens", chemicals that fall into a "D" category are also not assessed as carcinogens. Chemicals that are "C" carcinogens may be assessed with caution as carcinogens with an understanding of the conservatism and uncertainty involved with the associated database. In general, focus should be on carcinogens with classifications of A, B1, and B2.

SECTION 3

RISK ASSESSMENT APPLICATIONS

> Risk decisions are a commanders business. Such decisions are normally based on the next higher commands guidance on how much risk he is willing to accept and delegate for the mission.
>
> —FM 100-14, Risk Management

> Risk management is an effective process for preserving resources. It is not an event. It is both an art and a science.
>
> —FM 100-14, Risk Management

> A philosophy of dealing with any harm [to deployed personnel] should be clearly stated, widely disseminated, ethically based, practical, and comprehensive. This will allow commanders to make informed decisions and be flexible rather than having to deal with prescribed limits when they may be inappropriate or impractical . . .
>
> —Institute of Medicine (1999)

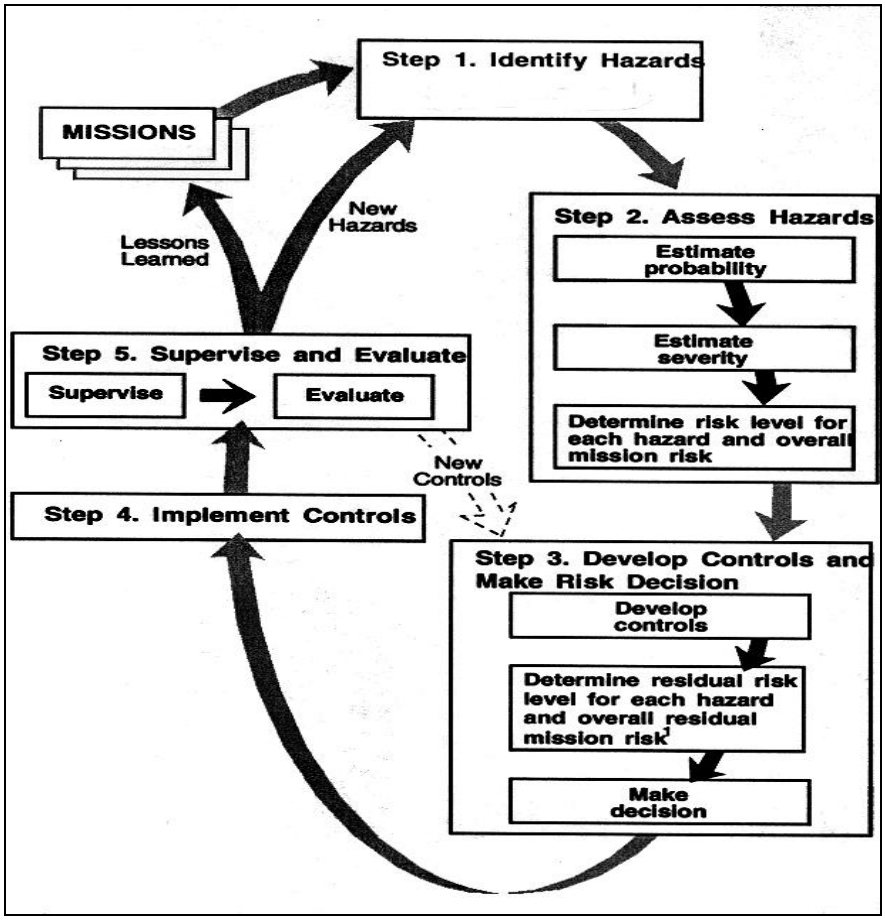
TG 230 MEGs are best utilized in risk assessments supporting ORM decisions. TG 230 should be used in concert with TG 248, which provides guidance for assessing and managing OEH hazards within the military ORM framework. TG 248 also identifies those preventive medicine tasks that support OEH surveillance and the responsibilities for various assets within the preventive medicine hierarchy.

3.1 OPERATIONAL RISK MANAGEMENT

Army risk management doctrine, as detailed in FM 100-14, provides commanders with methods to evaluate and manage the risks posed by operational hazards to the force. In addition, FM 3-100.4, *Environmental Considerations in Military Operations*, provides doctrine for managing environmental risks. These two documents provide an initial framework for characterizing environmental hazards. This framework is an iterative process that is integrated into operational planning and decision-making at all levels. Leaders manage risk by evaluating hazards and implementing ORM options during course of action (COA) development (see Figure 3-1).

The ORM approach is a process for identifying, assessing, and controlling risks as well as evaluating the effectiveness of risk control measures. This TG, in context of TG 248, addresses OEH chemical hazards that may pose health threats to individual troops. These can ultimately be expressed as medical threats to the force and the mission. The goal of TG 230 MEGs is to provide a useful tool to assist field commanders and their staff in the production of risk assessments and making informed ORM decisions that consider OEH hazards. Preventive medicine personnel should participate in the ORM process by identifying OEH hazards, assessing the threat associated with hazards, characterizing the risks in context of the proposed COA, effectively transmitting the risk assessments, and recommending appropriate control measure options to the commander. Preventive medicine personnel should also assist in implementing commander-selected control measures (e.g., provide health risk communication), evaluate effectiveness of control measures in controlling health threats, and document the ORM assessment to aid in subsequent re-assessments and in providing lessons learned for future deployments.

FIGURE 3–1. OPERATIONAL RISK MANAGEMENT PROCESS



3.2 HEALTH THREAT AND MEDICAL THREAT CONCEPTS

Health threats and medical threats represent different levels of importance to military operations. A health threat can cause negative health effects to a soldier. A medical threat is more severe and has the ability to render a field unit combat or mission ineffective, and lead to casualties reporting for medical diagnosis and treatment. Preventive medicine personnel must document assessments for both health threats and medical threats. For medical threats, preventive medicine must notify commanders of the mission impact, and most notify troop clinics and other medical treatment units of potential casualties. These terms are defined in FM 4-02.17, *Preventive Medicine Services*, as follows:

> ✍✍Health threat refers to an individual soldier's health. The term can include hereditary conditions that manifest themselves in adulthood, individual exposure to an industrial chemical or toxin where others are not exposed, or [conditions that can result in] other injuries and traumas that affect an individual's health but may not affect the health of the unit. On the other hand, a unit that experiences 40 to 50 percent of its personnel exhibiting a debilitating condition (e.g., salmonella poisoning), the unit can no longer complete its mission.

✍✍Medical threats are a sub-set of health threats that have the potential to degrade a unit's combat (or mission) effectiveness. Medical threat is defined as "a collective term used to designate all potential or continuing enemy actions and environmental situations that could adversely affect the combat effectiveness of friendly forces, to include wounds, injuries, or sickness incurred while engaged in a joint operation" (see Joint Publication 4-02, *Doctrine for Health Services Support in Joint Operations*). In Army and multi-service publications, the term is defined as a composite of all ongoing potential enemy actions and environmental conditions and disease and non-battle injuries (DNBI) that may degrade a unit's combat effectiveness. Commanders and unit leaders are responsible for protecting and preserving Army personnel and equipment against injury, damage, or loss that may result from food-, water-, and arthropod borne diseases, as well as environmental injuries (e.g., heat and cold injuries) and occupational hazards.

The TG 248 ORM framework intends to consider both kinds of threats; however, medical threats are more important to possible mission failure than non-medical health threats. On the other hand, controlling unit health threats *in toto* would be the focus of FHP and maintaining unit readiness.

3.3 MEGs AND OPERATIONAL RISK ASSESSMENTS

To reemphasize, this TG does not establish "standards" that must be strictly adhered to, nor do their use represent a comprehensive, health risk assessment. MEGs are one tool to be used by trained preventive medicine personnel who may be required to inform their commanders of potential adverse health effects caused by chemical environmental contaminants and to identify potential impacts on the mission. This TG provides the evaluation criteria and methods to facilitate appropriately cautious, yet defensible, logical and consistent decision-making. The decision to minimize the potential health risks by avoiding exposure to particular adverse environmental conditions or providing protective equipment will always need to be balanced against the requirements of the mission itself. These decisions are ultimately those of the commander. It is the health service or preventive medicine officer's role to ensure that the commander has the essential information to make the most appropriate decision.

The process of assessing and characterizing health risks from chemical exposures inherently involves significant data limitations, uncertainty, variability, and professional judgment. Therefore, this TG cannot provide absolute answers. But the consistent application of the framework described along with the technical information and concentration levels, as well as suggested interpretations, can lead to appropriate and defendable decision making. The process described below (and more importantly the hypothetical case studies in Appendix F) provide the user with the baseline information from which they can build personal experience.

This TG is an effort to take technically complex information regarding potential health risks from a variety of hazards and translate such information for use in the traditional, standardized military ORM paradigm. If appropriately used, this TG and the ORM process will ensure that risks of greater significance are given top priority. To do this, it is necessary that all hazards be initially identified. Once identified, the severity and probability of the hazards is assessed to determine overall degree of risk. Then all risks are evaluated, compared, and decisions made which often result in decisions to mitigate/prevent some risks while accepting others.

This section will assist medical/preventive medicine personnel in putting chemical hazards in proper perspective and relay appropriate information through command levels as well as to fellow personnel. The information in this TG will help minimize errors in judgment that could be made either by over-estimating chemical hazards as a result of perceptions or media hype, or, in contrast, ignoring such

hazards because they traditionally have not been a military concern. Proper assessment of chemical hazards and potential control actions can prevent or reduce DNBI to ensure long-term health of the force. Or, when other more significant risks are present, the 'acceptance' of risk associated with a chemical exposure can be clearly demonstrated with the ORM process described herein.

Each risk assessment should be prepared in context and support of a larger risk management effort. The key risk assessment steps within the larger FM 100-14 risk management process, as described in TG 248 (*Guide for Deployed Military Personnel on Health Hazard Risk Management*) were used as guidance and are outlined below:

1. *HAZARD IDENTIFICATION*
   - *1.1. METT-TC: chemicals, media, and locations*
   - *1.2. Preliminary threat analysis*
2. *HAZARD ASSESSMENT*
   - *2.1. Hazard severity evaluation*
   - *2.2. Hazard probability evaluation*
   - *2.3. Risk characterization*
     - *2.3.1. Estimate risk*
     - *2.3.2. Establish confidence level*
     - *2.3.3. Determine threat category*
3. *DEVELOP AND COMPARE CONTROLS FOR COA DEVELOPMENT*
   - *3.1. Develop hazard controls*
   - *3.2. Determine residual risks*
   - *3.3. Recommend actions to increase confidence in risk estimates*
4. *IMPLEMENT CONTROLS*
5. *SUPERVISE AND EVALUATE*

The following subsections summarize the requirements necessary to complete risk assessment Steps 1, 2, and 3. TG 248 and FM 100-14 provide procedures for health service activities in implementing ORM Step 4 (e.g., risk communication as part of implementing controls through), ORM Step 5 (e.g., assessing effectiveness of controls), and documentation of ORM activities.

3.3.1 *ORM STEP 1 — HAZARD IDENTIFICATION*

Step 1.1 METT-TC: Chemicals, Media, and Locations

An OEH chemical hazard is any chemical or chemical mixture that can cause injury, illness, disease, adverse health conditions, or death for personnel (health threats). Such conditions may also affect the health status of the Command (medical threats). During the intelligence preparation of the battlefield (IPB) in the application of METT-TC factors[1], the identification of an OEH chemical hazard involves the presumption or detection of an exposure to the chemical. Chemical hazards can be associated with different media (e.g., air, water, soil, food) and exposure routes. Exposures can occur via inhalation of airborne chemicals as mists, vapors, gases or solids (fumes or dusts). They can also occur via ingestion of drinking water or the inadvertent ingestion of soil. Dermal contact with some chemicals can also be a hazard under some conditions. Identification of these hazards can include collection of information through intelligence channels, field sampling, exposure or accident modeling, or a combination of all methods. TG 248 and TG 251 (*Draft Environmental Health Field Sampling Guide for Deployments*)

[1] METT-TC: Mission, Enemy, Terrain and Weather, Troops, Time, Civilian

provide additional guidance on gathering, organizing, and validating the following types of chemical hazard information:

?? Using field data to estimate exposure: The user of this TG should become familiar with the basis, assumptions, and limitations associated with the MEG values presented in the tables and should also be able to critically assess how representative field-collected sampling data is for characterizing actual personnel exposures. In many cases, a limited number of samples will be obtained, and it will require professional judgment of trained preventive medicine staff to determine what exposures are truly anticipated throughout the deployment. The ORM framework requires not only an assessment of the severity of a hazard (i.e., exposure concentrations below the guideline indicate a negligible hazard but higher concentrations could signify a minimal to moderate hazard), but it also requires an assessment of the probability of the hazard (i.e., exposure above the designated guideline). Though real-world scenarios cannot entirely separate issues of probability and severity, this TG focuses on aspects of assessing severity.

?? Understanding the population of concern: To use these guidelines, field data should also include information about the population of concern (who/what percent of the overall unit is at risk of exposure and what operations will they be involved with that could affect how they are exposed). The user needs to evaluate the anticipated exposure durations at given concentrations, as this will be important in determining the overall severity of the hazard.

?? Pesticide use and surveillance: Some unique activities involve intentionally placing chemicals in the environment. Pesticide contamination due to pest control operations may lead to chemical residues in the environment. Of particular concern in this regard is pesticide contamination caused by host nation activities in an area subsequently occupied by U.S. Forces supporting a contingency operation. It is critical that initial levels of pesticide contamination in such areas be recorded prior to initiation of pest control operations to facilitate distinguishing between prior contamination and any accidental contamination caused by pest control operations in support of U.S. activities. It is important to note that pesticide contamination in a given area does not necessarily obviate the need for additional chemical pest control in that area. Pest and disease vector populations, though present in the vicinity of a contaminated site, often exist in microhabitats that are completely isolated from the contaminated zones, and so are not exposed to the contaminant. Thus, targeted pest control operations may still be warranted in such scenarios.

Step 1.2 Preliminary Threat Analysis

The purpose of this sub-step is to prioritize identified OEH hazards so that the risk assessment focuses on the most important threats first. In order to focus additional risk characterization efforts and possible data collection, the risk assessor must determine which of the identified chemical hazards pose HEALTH THREATS to personnel under site-specific conditions or are MEDICAL THREATS to the mission. The three types of threat classifications for OEH hazards are presented below and in Figure 3-2.

✍✍NO CHEMICAL HEALTH THREAT can be assigned to a chemical hazard only when there is no evidence to indicate its presence in the environment of concern or there is enough data to know that the concentration and extent of its presence would not pose a credible health threat.

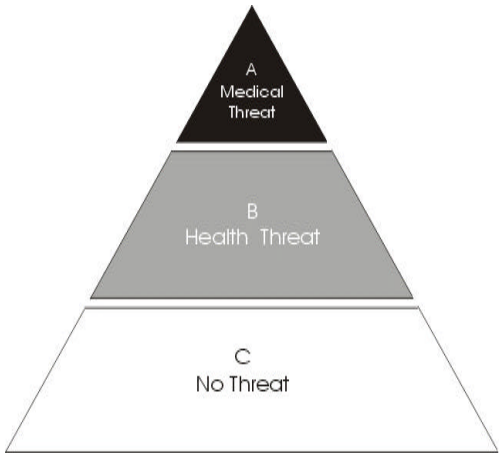
✍✍CHEMICAL HEALTH THREATS are all identified chemicals within the AO that, under plausible circumstances, could result in adverse health effects to certain individuals. For example, a chemical hazard may result in temporary mild headaches or nausea to certain sensitized individuals or may induce health effects with delayed onset (e.g., chronic diseases like cancer or impaired liver and kidney function) but have no immediate, mission impacting effect.

Commanders may still choose to incorporate such hazards into his or her risk management process, regardless of immediate impacts to the mission (e.g., during operations other than war).

✍✍CHEMICAL MEDICAL THREATS Depending on the mission, such hazards include chemical exposures that might result in effects such as severe eye irritation/blurred, vision, severe dizziness/confusion, seizures, death, or would otherwise result in sick calls or medical interventions.

FIGURE 3–2

Hierarchy of OEH Hazards to the Military



Determining OEH hazard categories:

In general, if concentrations of a detected chemical consistently fall below the 1-year MEG values, then one may assume that the identified OEH hazard does not pose a health threat. Therefore, the use of the 1-yr MEG values to "screen" identified chemicals/hazards of concern is encouraged before the risk assessment proceeds into Step 2 (Hazard Assessment). If exposures will not last longer than 14 days, then use of the 14-day MEGs is acceptable to "screen" for the occurrence of a health threat before proceeding. In all cases, professional judgment in selecting the most appropriate guidelines for comparison is required. In many cases, the operational risk assessment can end at this stage if it can be demonstrated that the exposure concentrations do not pose a health threat to personnel. There are many uncertainties that must be considered in such determinations. For example, there will be a variety of situations where actual exposures are not consistent with those in the guidelines.

?? Estimating the exposure concentration to compare to the MEG. Environmental monitoring may indicate fluctuations in actual concentrations over time. The MEGs should be compared with the most representative exposure concentration associated with the actual scenario of concern. While averaging exposure levels spatially and temporally is one appropriate way to look at data, it should be noted that peaks of short duration may have health effects—so the user should assess data against all guidelines and durations at this stage in the process. If any MEG is exceeded, then in most cases that exposure scenario should proceed to Step 2 of the process. The hypothetical case studies in Appendix F provide some guidance as to how this can be accomplished.

?? Multiple chemical exposures. Each MEG has been established to be protective against exposure to a single chemical. The complex issue of multi-chemical exposures and effects of chemical interactions is beyond the scope of the TG, but such effects should be considered in the overall evaluation of environmental exposures. Since certain contaminants may have similar adverse effects on the human body, it is necessary to consider the total sum of all similar effects. Unfortunately, little is known regarding the specific interactions of multiple contaminants. A specific quantitative technique for assessing multiple contaminants in a deployment setting is not feasible at this time. Instead, users are encouraged to note the possibility of added hazards, particularly where chemicals have similar effects or known interactions are listed. This information should be used in conjunction with professional judgment. (Interactions are notated in the "Notes" column of the MEG tables. In particular, note the target organ column.) If two or more chemicals have the same target organs or systems (see Section 2.4.2) , then it may be considered that their effects can be additive or synergistic. For some specific chemicals, such as

total petroleum hydrocarbon (TPH) compounds or carcinogens (particularly those with an A or B WOE classification) it is generally assumed that effects of the different chemicals when combined are at least additive.

?? Multiple exposure pathways. In addition to the potential additive effects of multiple contaminants, military personnel may be exposed to the same contaminants from multiple sources (e.g., air, water, and soil). The effects of exposure to the same or similar chemicals through different media should be considered additive. Users are encouraged to note that exposure (through multi-media) may increase overall exposure. This information can be used when ranking OEH hazards.

?? Chemical hazards without MEG values. Where this TG lacks a MEG for an identified chemical, we recommend the health staff follow these steps: (1) contact USACHPPM for assistance in establishing a MEG; (2) research the chemical (e.g., literature or internet resources) and establish a surrogate MEG; (3) establish a risk estimate based on similar chemicals in this TG and document the uncertainty (i.e., reduced confidence) in the risk characterization (Sub-step 2.3). Additional information is provide in Section 1.4.4.

3.3.2 *STEP 2 — HAZARD ASSESSMENT*

OEH hazards that proceed into this step of the operational risk assessment will usually be present in air, water, or soil at concentrations greater than 1-yr or 14-day MEG values depending on the duration of the exposure.

Step 2.1 Hazard Severity Evaluation

An OEH chemical hazard severity category represents "the potency of the chemical to cause injury, illness, disease, adverse health conditions, or death integrated with the significance of the health consequences for personnel relative to the ability of the field unit to complete the mission or maintain readiness" (TG 248, 2001).

When field concentrations exceed 1-year MEGs, users must attempt to estimate the severity of the health threat. For air and drinking water, users should first determine whether any short-term standards are also exceeded. If the exposure duration is 1 year and a 14-day, 8-hour, or 1-hour MEG is exceeded, then some significant health and/or mission impacts may be anticipated. For many chemicals with long-term guidelines, however, there are no parallel short-term guidelines. In such cases, the user may have to rely on professional judgment as to the severity of the hazards. In practice, any "conclusion" and estimation of the severity of health threat must be made with an understanding of the limitations of currently available data that forms the basis of the MEG and of the risk-assessment process in general. Appendix F provides examples of how hazard severity can be determined.

A chemical's hazard severity is a function of the consequence of exposure for any given individual in the unit and the predicted distribution of that impact within the field unit. Unfortunately there is often limited human toxicological or epidemiological data for most chemicals, and limited information regarding human response variability and genetic susceptibilities to most chemicals, making it difficult to know specifically what health effects to anticipate or, even more difficult, to ascertain the percentages of an exposed population that will exhibit certain effects. However, to the extent possible, the following considerations will need to be factored into assigning a hazard severity category to a chemical hazard.

?? Proportion of the field unit that is likely to exhibit effects relative to the specific exposure guidelines.

?? Nature of the health effect(s) associated with exposures at or above the guideline level.

?? Confidence in the available data, given the sources of uncertainty and variability.

Based on these considerations, one of the following categories from FM 100-14 should be assigned to an identified chemical hazard:

CATASTROPHIC — Loss of ability to accomplish the mission or mission failure.
CRITICAL — Significantly (severely) degraded mission capability or unit readiness.
MARGINAL — Degraded mission capability or unit readiness.
NEGLIGIBLE — Little or no adverse impact on mission capability.

The Hazard Severity Ranking Chart presented in Table 3-1 is a recommended approach:

TABLE 3-1. CHEMICAL HAZARD SEVERITY RANKING CHART FOR MILITARY DEPLOYMENTS

MAGNITUDE OF CHEMICAL CONCENTRATION							
	WATER	< MEG	= MEG that is not based on TB MED 577 (See Water Note)		= MEG that is based on TB MED 577 (See Water Note)	See Water Note	See Water Note
	SOIL	< MEG	= MEG (See Soil Note)		See Soil Note	See Soil Note	See Soil Note
	AIR	< 1-yr MEG or < 14-day MEG	= 1-yr MEG or = 14-day MEG but = 1 to 24-hr Min-MEGs	≥ 1-yr MEG or ≥14-day MEG but > 1 to 24-hr Min-MEGs	> 1-hr Min-MEG but ≤ 1-hr Sig-MEG	>1-hr Sig-MEG but = 1-hr Sev-MEG	> 1 hr Sev-MEG
IN GENERAL, THE ASSOCIATED HEALTH OUTCOME ATTRIBUTIBLE TO EXPOSURE (Percentages are very uncertain and will vary by chemical and other confounding factors.)		No cases of illness or non-cancer disease and less than 1 cancer case in 10,000	0 – 10 % of personnel may develop illness or chronic disease	0 – 10 % of personnel may develop mild illness or temporary irritation	> 10 % of personnel may experience mild illness, irritation AND 0 – 10 % of personnel may develop more severe illness that begins to impair functional abilities.	10 – 25 % of personnel may experience severe illness or irritation and more noticeable degradation of performance capabilities AND Other personnel will, at least, suffer some mild effects	> 25 % of personnel may experience severe, incapacitating effects AND Fatalities will begin to occur just above the Sev Air-MEG with increasing number of fatalities as concentrations increase
ONSET OF SYMPTOMS		After the Mission		During the Mission			
HAZARD SEVERITY RANK		NONE	NEGLIGIBLE		MARGINAL	CRITICAL	CATASTROPHIC
HAZARD TYPE		NO HEALTH THREAT	HEALTH THREAT		MEDICAL THREAT		

WATER NOTE: Concentrations greater than the MEG *may* result in Hazard Severity from Marginal to Catastrophic if certain chemicals are present in high enough quantities and there is sufficient consumption. Additional information in the Notes column of the MEG Tables should be evaluated regarding effects of higher levels of exposure.

SOIL NOTE: Soil is unlikely to represent a hazard that would yield a Medical Threat. Additional information in the Notes column of the MEG Tables should be evaluated for data regarding higher levels of exposure.

Min-MEG: minimal effects level from Appendix C, Tables C-1 & C-2.
Sig-MEG: significant effects level from Appendix C, Tables C-1 & C-2.
Sev-MEG: severe effects level from Appendix C, Tables C-1 & C-2.
1-yr MEG: values from Table C-3.

Step 2.2 Hazard Probability Evaluation

An OEH chemical hazard probability category represents "the magnitude, frequency and duration of personnel exposure to the identified chemical(s) integrated with the expected incidence of exposure within the unit relative to associated guideline levels" (TG 248, 2001).

Determining the chemical hazard probability category will generally be a very subjective evaluation, where three primary considerations are used to determine the potential degree of exposure:

?? Comparability of the field unit's exposure profile (exposure factors, frequencies, and durations) to the standard exposure profile used in the derivation of the exposure guideline(s) of concern.

?? Proportion of the field unit that is likely to experience exposures relative to the specific exposure guidelines.

?? Confidence in the available data, given the sources of uncertainty and variability.

Based on these considerations, one of the following categories from FM 100-14 should be assigned to an identified chemical hazard to indicate the probability of personnel exposures to concentrations equal to or greater than the MEGs:

FREQUENT — Occurs very often, continuously experienced
LIKELY — Occurs several times
OCCASIONAL — Occurs sporadically
SELDOM — Remotely possible; could occur at some time
UNLIKELY — Can assume will not occur, but not impossible

The following Hazard Probability Ranking Chart (Table 3-2) is based on TG 248, and is a recommended approach than can be altered as the situation dictates.

TABLE 3-2. CHEMICAL HAZARD PROBABILITY RANKING CHART FOR MILITARY DEPLOYMENTS

PERCENT OF PERSONNEL THAT WILL EXPERIENCE EXPOSURES TO CONCENTRATIONS EQUAL TO OR GREATER THAN THE MEG*				
<10%	10< 25 %	25 <50 %	50 <75 %	>75 %
Unlikely	Seldom	Occasional	Likely	Frequent

*Determination of the percent of personnel exposed to a chemical or mixture specifically above a guideline level can be based on modeling, gridding, or generalized assumptions.

Step 2.3 Risk Characterization

Step 2.3.1 Estimate Risk

The risk level is estimated using the probability and severity information from the previous sections. The primary objective is to apply the FM 100-14 Risk Assessment Matrix (Table 3-3) in a way that is consistent with operational guidance, so that OEH risks can be put in the same context as other operational risks.

ORM risk levels defined in FM 100-14 (Table 3-3) are presented with unit status suggestions from FM 101-5-1 in Table 3-4 to create an OEH risk characterization paradigm that is consistent with current operational doctrine. The concept of unit strength status (e.g., "below 50% strength") refers to the overall loss of resources that would otherwise be directed towards the planned mission tasks. For every casualty (i.e., significant through severe effects that result in functional loss) one can expect the loss of additional personnel due to medical and related support for that casualty.

TABLE 3-3. RISK ASSESSMENT MATRIX (FM 100-14)

HAZARD SEVERITY		HAZARD PROBABILITY				
		Frequent (A)	Likely (B)	Occasional (C)	Seldom (D)	Unlikely (E)
		?	**?**	**?**	**?**	**?**
Catastrophic (I)	**?**	Extremely High	Extremely High	High	High	Moderate
Critical (II)	**?**	Extremely High	High	High	Moderate	Low
Marginal (III)	**?**	High	Moderate	Moderate	Low	Low
Negligible (IV)	**?**	Moderate	Low	Low	Low	Low
		RISK ESTIMATE				

Some past interpretations of the FM 101-5-1 unit status definitions have placed the lethal concentration for half of the population (LC_{50}) as the point at which a Catastrophic hazard - Extremely High risk would begin. This interpretation ignores two facts: (1) with a 50 % mortality rate due to chemical exposure, there would also be a large percentage of personnel with significant health effects other than death that would likely cause incapacitation and (2) medical support would be required to tend to those who were injured. As a result, at an LC_{50} concentration, unit strength would be much less than 50 percent resulting in possible complete combat ineffectiveness. Therefore, the MEGs presented in this TG are based on thresholds for the various types of effects noted (e.g., the 1-hour severe Air-MEG refers to approximately a 1% lethality concentration (LC_{01}) for an exposed population). Some may view this as a conservative interpretation of the FM 101-5 unit status codes and FM 100-14 risk definitions, but this does address a more comprehensive assessment of the true, overall impact on unit resources and combat effectiveness.

TABLE 3-4. RISK LEVEL DEFINITIONS

Risk Level	Defined Consequence (FM 100-14)	Unit Status (FM 101-5-1)
Extremely High	Expected loss of ability to accomplish the mission.	Black (Unit Requires Reconstitution). Unit below 50% strength.
High	Expected significant degradation of mission capabilities in terms of the required mission standard, inability to accomplish all parts of the mission, or inability to complete the mission to standard if hazards occur during the mission.	Red (Combat Ineffective). Unit at 50 – 69 % strength.
Moderate	Expected degraded mission capabilities in terms of the required mission standard will have a reduced mission capability if hazards occur during mission.	Amber (Mission Capable, with minor deficiencies). Unit at 70 - 84% strength.
Low	Expected losses have little or no impact on accomplishing the mission.	Green (Mission Capable). Unit at 85% strength or better.
The unit rates provided under Unit Status are to be determined by the commander. Charts similar to the example OEH Hazard Probability and Severity Ranking Charts presented above should be aligned with the acceptable risk levels provided by the commander.		

Step 2.2.2 Determine Confidence in Risk Estimate

A confidence level should be assigned to each risk estimate. The degree of confidence will be particularly important when determining possible courses of action. Confidence levels should be simple categories that can be rationally explained (e.g., high, medium, low). The confidence level assigned to a risk estimate should integrate uncertainty associated with each of the elements of the risk assessment. Key areas of uncertainty that should be considered include:

- ?? Sampling or field data quality
- ?? Actual exposures of field personnel
- ?? Field unit attributes (e.g., demographics, activity patterns)
- ?? Comparability of standard guideline assumptions (e.g., exposure duration, exposure frequency, and route of exposure) to expected field exposure patterns
- ?? Expected symptoms of exposure (i.e., hazard severity), including consideration of exposure to multiple hazards
- ?? Other uncertain, or missing, information relevant to the process
- ?? Whether the predicted health outcome is plausible, given weight of evidence or real-world experiences

Table 3-5 provides example criteria for determining a risk estimate confidence level. The final determination of confidence should be based on well-reasoned judgment of the staff officer conducting the risk assessment. As stated previously, it is important for the user to realize that - due to limitations in toxicity data, the nature of chemical exposures, and human variability - OEH chemical risk assessments should almost never be ranked with high confidence. For the most part, the MEGs are conservatively designed so that confidence in estimated *Low Risks* will tend to be greater than those estimated to be *High Risk*.

TABLE 3-5. EXAMPLE CRITERIA FOR ASSIGNING CONFIDENCE LEVELS

Confidence Level	Criteria
High	Sampling data quality is good. Field activity patterns are well known. True exposures are reasonably approximated. Knowledge of the symptoms of hazard exposure relative to guideline is well known. No important missing information. The predicted health outcome is plausible or already demonstrated.
Medium	Field data quality is good. Field exposures are likely to be overestimates of true exposures due to incomplete data coverage relative to actual exposure durations. Detailed information is lacking regarding true personnel activity patterns in the field. Symptoms are well known for each individual hazard, but some scientific evidence suggests that the combined effects of all hazards may exacerbate symptoms. Predicted health outcome is plausible.
Low	Important data gaps and/or inconsistencies exist. Exposure conditions are not well defined. Field personnel activity patterns are basically unknown. Predicted health outcome is not plausible because it is not consistent with real-world events/experience.

Step 2.3.3 Determine Threat Category

During Step 1 (Hazard Identification), a preliminary threat analysis was conducted for each of the identified chemical hazards. During Step 1 the goal was to determine which of the hazards have a credible potential to become HEALTH THREATS or MEDICAL THREATS in order to focus additional data collection and risk characterization efforts. At this point in the process, the preliminary analysis should be re-evaluated based on the more complete assessment of the nature of the hazards and the conditions of exposure. The placement of the hazards into health threat categories (no threat, health threat, and medical threat) is the last step in risk characterization. It is important for the command to understand that some hazards pose a greater potential to operations than others, even though the risk estimates may be similar. The command will have a preference to control medical threats over health threats. This sub-step is designed to provide the command with a useful ranking of the hazards faced by the unit and mission.

3.3.3 *Step 3 — Developing and Comparing Controls*

Risks are managed by either choosing the least risky COA and/or by incorporating control measures into one or more of the COAs that will address any identified environmental and occupational risks. Chemical hazard risk management strategies will fall into one of five general categories (Table 3-6).

TABLE 3-6. RISK MANAGEMENT STRATEGIES

RISK MANAGEMENT STRATEGIES	ATTRIBUTES
No Action	An implicit acceptance of the risk by the command.
Reduce Risk	Allowing exposures to occur but using control measures to reduce hazard severity and/or probability so as to reduce the true risk to a more acceptable level.
Avoid/Prevent Exposure	Use of engineering or administrative methods to prevent or completely avoid exposures of concern.
Interim Controls and Risk Re-assessment	Any combination of the above measures can be used as an interim action to address predicted risks that are of low confidence while obtaining additional data to increase the confidence in the risk estimate(s) before final decisions are made.
Health Surveillance	Use of medical and environmental surveillance systems to monitor ambient conditions (e.g., routine air monitoring) or personnel (e.g., bio-monitoring). This is not a means to directly control chemical hazards, but it can provide information to support or change a chosen risk management strategy.

Step 3.1 Develop Chemical Hazard Controls

Selection of possible control measures will be situation-specific and will involve a balancing of resources based on costs and benefits, consideration of time constraints, and appreciation of other real-world issues such as political sensitivities. To be effective each control developed must meet criteria for suitability, feasibility, and acceptability (FM 100-14). For a control to be suitable it must actually remove the hazard or mitigate the residual risk to an acceptable level. Feasible controls are those that the unit is capable of implementing. Acceptable controls are those that justify the costs of resources and time. Acceptability of controls is a command decision. Table 3-7 provides examples of control measures that can be used for dealing with chemical hazards.

TABLE 3-7. EXAMPLES OF CHEMICAL HAZARD CONTROL MEASURES

ADMINISTRATIVE	ENGINEERING	PERSONAL PROTECTIVE EQUIPMENT
Moving location of operations	Substitute use of less hazardous materials	MILITARY PROTECTIVE MASK (M-40,M-17)**
Managing deployment length/work schedules	Use of ventilation/increase dispersion	Commercial respiratory protection
Providing prophylactics/medical interventions that will reduce severity of effect	Isolate areas/build barriers or enclosures to prevent chemical release or human exposures	Eye protection
Enforcing personal hygiene standards	Use of filters (air or water purification systems)	Chemical protective Clothing
Active dust suppression measures		Normal battle dress uniforms (BDUs)/gloves

** NOTE: The military protective mask is only approved for against NBC-warfare agents; it may not offer adequate protections against other TICs.

Step 3.2 Estimate Residual Risks

Once suitable and feasible hazard control options are identified, the residual risk(s) associated with the implementation of the controls must be assessed. This process is a basic re-iteration of Steps 1 and 2 of the process. Possible control measures, or other risk management strategies, should be communicated to the command with the associated residual risk estimates.

Step 3.3 Recommend Actions to Increase Confidence in Risk Estimates

While in almost all cases there will be data gaps that can be improved with additional data, it is understood that there are logistical and time constraints that will require decisions to be made without the opportunity to increase confidence with more data. Because risk assessments are inherently uncertain, ways to reduce critical uncertainties should be explored if the risk assessment confidence levels are low to medium. This is particularly important if the generated risk estimates are high or extremely high, as control measures will require significant actions that dramatically impact the mission or involve notable resource expenditures, and there is reason to believe that specific types of data will be able to improve the confidence level. In these cases, additional data can either reduce the risk estimate or provide stronger justification of a need for drastic control measures.

3.3.4 *Steps 4 and 5 - Implementing Controls; Supervising And Evaluating*

Implementing the course of action selected during Step 3 requires a command decision, but to be successful will generally require continuous input and assessment by various staff elements who may at times need to recommend alternative decisions. Courses of action may include decisions to accept exposures or to avoid them by leaving an area, minimize them through use of protective measures, and/ or document them by performing routine monitoring. Each of these will have impacts to the mission, whether it is from use of limited resources (such as conducting regular monitoring) or impacts to morale and overall physical wellness. PM responsibilities should consider these impacts during Step 3, but must evaluate the situation once the action is initiated. Additional requirements, such as health risk communications briefings to personnel and/or command staff, may be identified through these continued evaluations. Some of the Hypothetical Case Scenario Examples in Appendix F demonstrate these final steps of the ORM process.

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APPENDIX A

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APPENDIX B

GLOSSARY OF TERMS AND ACRONYMS

Glossary of Terms (Acronyms begin on B-7)

Acidosis
Decrease of alkali in the blood, which may result in a decrease in the pH. Symptoms include very deep respirations, dehydration, drowsiness, stupor, or coma.

Anorexia
Loss of appetite.

Anoxia
Lack of oxygen.

Anuria
Complete urinary suppression or failure of kidney function.

Ataxia
Inability to coordinate muscles in movement.

Azotemia
An excess of urea and other nitrogenous waste in the blood resulting from kidney damage or failure.

Blepharospasm
A twitching or spasmodic contraction of eyelid.

Bradycardia
Abnormally slow heartbeat below a rate of 60 beats per minute.

Cachexia
A state of ill health, malnutrition and wasting.

Cardiac Arrhythmia
Absence of heartbeat.

Cardiac Dysrrhthmia
Irregular heartbeat.

Cardiac Ischemia
Abnormally low flow of blood to the heart.

Chloracne
Acne-like disruptions over the body resulting from exposure to certain chlorinated hydrocarbons such as dioxins.

Cholestasis
Blockage of the flow of bile resulting in increases of bilirubin in the blood.

Cyanosis
Bluish discoloration of the skin resulting from a deficiency of oxygen in the blood.

Desquamation
Shedding of outer layer of skin.

Dysphagia
Difficulty in swallowing.

Dysphonia
Difficulty in speaking; hoarseness.

Epigastric
Refers to the upper central portion of the abdomen between the lower ribs and the umbilicus (belly button).

Epistaxis
Nose bleed.

Erythemia
Redness of the skin.

Gastroenteritis
Inflammation of the stomach and intestines, usually accompanied by vomiting and diarrhea.

Hematuria
Blood in the urine.

Hemoglobinuria
The presence of hemoglobin the urine.

Hemolytic Anemia
Abnormal destruction of red blood cells resulting in a decrease in the number of cells in the blood and presence of free hemoglobin, which can lead to acute renal failure.

Hemoptysis
Spitting of blood arising from hemorrhage of the larynx, trachea, bronchial tubes, or lungs.

Hyperplasia
Abnormal but non-cancerous increase in the number of cells in a tissue or organ.

Hypertension
Elevated blood pressure.

Hyperthermia
Elevated body temperature.

Hypotension
Reduced blood pressure.

Hypothermia
Decreased body temperature.

Hypoxemia
Insufficient oxygenation of the blood.

Immunosuppression
Suppression of the immunologica response, leading to decreased resistance to disease.

Jaundice
A yellow staining or darkening of the skin, whites of the eyes, and excreta due to increased bile pigments in the blood and tissues.

Lassitude
Lethargy, apathy, exhaustion.

Leukopenia
Reduction in number of circulating white blood cells (the cells which fight infection).

Malaise
Discomfort, uneasiness indicative of infection or other disease.

Methemoglobinemia
Condition in which the oxidation state of iron in hemoglobin is abnormal leading to decreased availability of oxygen to the body tissues.

Miosis
Contraction of the pupil (pin-pointed pupil).

Monocytosis
Excessive number of monocytes (a type of white blood cell) in the blood.

Mucosa
Mucous membrane; membrane lining bodily channels that communicate with air (i.e., mouth, respiratory tract, eye); glands of mucous membranes secrete mucous.

Mydriasis
Dilation of the pupil.

Narcosis
Stupor or deep unconsciousness; can be caused by exposure to a number of chemicals. Differs from anesthesia which refers to the loss of sensation (e.g., pain) or touch and can be local or general.

Nephritis
Inflammation of the kidney.

Pallor
Paleness of the skin.

Palpitation
Perceptible irregular or rapid beating or pulsation of the heart.

Paresthesia
Burning prickling, tingling, or tickling sensation.

Paroxysmal
Recurring in sudden, periodic attacks or intensification of symptoms of a disease.

Photophobia
Unusual intolerance to light.

Polyneuropathy
Disease involving a number of peripheral nerves (e.g., nerves in the hands, feet or legs).

Porphyria Cutanea Tarda
A metabolic disorder in which reddish pigments or porphyrins are produced in the liver. The excess pigments accumulate in the skin where they are activated by visible light which causes photosensitive skin reactions characterized by skin erosions and blistering. These painful sores resolve slowly and may result in scarring, hair loss, and skin atrophy. Excess porphyrins are excreted in the urine which becomes colored dark red or brown as a result.

Precordial
Pertaining to the region over the heart and lower part of the thorax.

Prostration
Marked loss of strength; exhaustion.

Pulmonary Edema
Buildup of fluid in the lung.

Retrosternal
Behind the sternum.

Spasticity
Hypertonicity of muscles causing stiff and awkward movements.

Spermatogenesis
Development of sperm cells.

Stenosis
Constriction or narrowing of a passage or orifice.

Syncope
A transient form of unconsciousness during which the person slumps to the ground resulting from cerebral anoxia (insufficient oxygen in the brain).

Tachycardia
Excessively rapid heartbeat.

Tinnitus
Noise (typically ringing) in the ears.

Urogenital tract
Denotes the organs involved in reproduction and urination.

Ventricular Fibrillation
Rapid contractions or twitching of the muscle fibers that replace normal contraction of the ventricular chambers of the heart.

Vertigo
Dizziness; sense of spinning.

Vesiculation
Formation of a small blister-like small elevation on the skin containing serous fluid.

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Acronyms

ABS	Skin Absorption Factor
ACGIH	American Conference of Governmental Industrial Hygienists
AF	Adherence Factor
AMEDD	Army Medical Department
AO	Area of Operation
AQI	Air Quality Index
ARNG	Army National Guard
AT	Annual Training
ATSDR	Agency for Toxic Substances and Disease Registry
BAP	Benzo(a)pyrene
BC	Base Camp
BDU	Battle Dress Uniform
BUN	Blood Urea Nitrogen
BW	Body Weight
CHID	Chemical Hazard Information for Deployments
ChE Inh	Cholinesterase Inhibitor
cm^2	square centimeter
cm^3	Cubic centimeter
CNS	Central Nervous System
CO	Carbon Monoxide
COA	Course of Action
CONUS	Continental United States
cPAHs	Carcinogen Polycyclic Aromatic Hydrocarbons
CRC	Circulatory System

CS	Case Study
CSFi	Carcinogen Inhalation Slope Factor
CVS	Cardiovascular System
CWA	Chemical Warfare Agent
DA	Department of the Army
DESP	Deployment Environmental Surveillance Program
DNBI	Disease and Non-Battle Injury
DOD	Department of Defense
DODI	Department of Defense Instruction
ED	Exposure Duration
EEG	Electroencephalogram
EF	Exposure Frequency
EKG	Electrocardiogram
ENDO	Endocrine System
FDWS	Field Drinking Water Standards
FHP	Force Health Protection
FM	Field Manual
GI	Gastrointestinal
gm	gram
g/kg	gram per kilogram
g/L	gram per Liter
GPL	General Population Limit
HC	Hexachloroethane
HEAST	Health Effects Assessment Summary Tables
HEM	Hemopoietic System

HQDA	Headquarters Department of the Army
hr	Hour
HSDB	Hazardous Substance Databank
IDLH	Immediately Dangerous to Life and Health
IMM	Immune System
IOM	Institute of Medicine
IPB	Intelligence Preparation of the Battlefield
IRIS	Integrated Risk Information System
kg	kilogram
L	Liter
L/day	Liters/day
LC_{50}	Lethal Concentration for 50 percent of the exposed population
LC_{01}	Lethal Concentration for 1 percent of the exposed population
LD	Lethal Dose
LD_{50}	Lethal Dose for 50 percent of the exposed concentration
LD_{LO}	Lethal Dose –low (approximate low percentage e.g. 1-5%) lethalities amongst exposed
LOAEL	Lowest-Observed Adverse Effect Level
LOEL	Lowest-Observed Effect Level
LOG	Logistics
LRS	Lower Respiratory System
MEGs	Military Exposure Guidelines
METT-TC	Mission, Enemy, Terrain and Weather, Troops, Time, Civilian
MRL	Minimal Risk Level
Min	Minimal
m^3/day	cubic meter per day

?g/dl	microgram per decaliter
?g/kg	microgram per kilogram
?g/L	microgram per Liter
mg	milligram
mg/cm^2	milligram per square centimeter
mg/day	milligram per day
mg/kg	milligram per kilogram
mg/kg/day	milligram per kilogram per day
mg/L	milligram per Liter
mg/m^3	milligram per cubic meter
ml	milliliter
µm	micrometer
NAAQS	National Ambient Air Quality Standards
NBC	Nuclear, Chemical, Biological
NCO	Non-commissioned Officer
ND	Not determined
NO_2	Nitrogen Dioxide
NOAEL	No-Observable Adverse Effect Level
NRC	National Research Council
NTU	Nephelometric Turbidity Units
O_3	Ozone
OCONUS	Outside the Continental United States
OEH	Occupational and Environmental Health
OPORD	Operation Order
OPLAN	Operation Plan

ORM	Operational Risk Management
OSHA	Occupational Safety and Health Administration
PAH	Polycyclic Aromatic Hydrocarbons
Pb	Lead
PCB	Polychlorinated Biphenols
PEGL	Permissible Exposure Guidelines Level
PEL	Permissible Exposure Limit
PM	Particulate Matter
PNS	Peripheral Nervous System
PPE	Personal Protective Equipment
ppb	parts per billion
ppm	parts per million
QSTAG	Quadripartite Standardization Agreement
RBC	Risk Based Concentration
RD	Reference Document
Recon	Reconnaissance
RfC	Reference Concentration
RO	Reverse Osmosis
ROWPU	Reverse Osmosis Water Purification Unit
RS	Respiratory System
SA	Surface Area
SASO	Stability and Support Operations
Sev	Severe
SGOT	Serum glutamic-oxaloacetic transaminase
SGPT	Serum glutamate pyruvate transaminase

Sig	Significant
SO_2	Sulfur Dioxide
SOH	Safety and Occupational Health
STANAG	Standardization Agreement
TB MED	Technical Bulletin, Medical
TEF	Toxicity Equivalence Factor
TG	Technical Guide
TICs	Toxic Industrial Chemicals
TLVs	Threshold Limit Values
TON	Threshold Odor Number
TPH	Total Petroleum Hydrocarbons
TSCA	Toxic Substance Control Act
TT	Treatment Technique
TWA	Time-Weighted Average
TWPS	Tactical Water Purification System
UD	Under Development
UF	Uncertainty Factor
URS	Upper Respiratory System
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
USEPA	U.S. Environmental Protection Agency
UT	Urogenital Tract
WOE	Weight-of-Evidence
WPL	Worker Population Limit
WQAS-PM	Water Quality Analysis Set-Preventive Medicine
yr	Year
$ZnCl_2$	Zinc Chloride

APPENDIX C

MILITARY EXPOSURE GUIDELINES FOR AIR

CONTENTS

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TABLE C-1. AIR MILITARY EXPOSURE GUIDELINES FOR CHEMICAL WARFARE AGENTS

Chemical CAS No.	Air-MEG Health Effect Level	10-Minute mg/m^3 [ppm]	1-Hour mg/m^3 [ppm]	8-Hour mg/m^3 [ppm]	24-Hour mg/m^3 [ppm]	Potential Symptoms and Target Organs/Systems	Notes
GA (Tabun) 77-81-6	MINIMAL	0.0069 [0.0010]	0.0028 [0.00042]	0.0010 [0.00015]	0.0003 [0.00005]	Running nose; tightness of chest; miosis and dim vision; difficulty breathing; drooling and excessive sweating; nausea, vomiting; CNS effects.	Based on relative potency from GB (see text for more information); (EPA 2001) 24-hour MEG estimate derived from 8-hour AEGL by straight-line extrapolation of 8-hour AEGL Ct (see EPA 2001 and document text) Existing (Recommended) IDLH = 0.2 (0.1) mg/m^3
	SIGNIFICANT	0.087 [0.013]	0.035 [0.0053]	0.013 [0.0020]	0.004 [0.00067]		
	SEVERE	0.76 [0.11]	0.26 [0.039]	0.10 [0.015]	0.03 [0.005]	Local effects to pupil of the eye; Respiratory system, CNS	

Chemical CAS No.	Air-MEG Health Effect Level	10-Minute mg/m^3 [ppm]	1-Hour mg/m^3 [ppm]	8-Hour mg/m^3 [ppm]	24-Hour mg/m^3 [ppm]	Potential Symptoms and Target Organs/Systems	Notes
GB (Sarin) 107-44-8	MINIMAL	0.0069 [0.0012]	0.0028 [0.00048]	0.0010 [0.00017]	0.0003 [0.000057]	Running nose; tightness of chest; dimness of vision and miosis; difficulty in breathing; drooling and excessive sweating; nausea, vomiting; cramps and involuntary defecation or urination; twitching, jerking and staggering; headache, confusion, drowsiness; at high exposures, coma and convulsion, leading to cessation of breathing and death	Minimal Level: Reversible miosis, headache, eye pain, rhinorrhea, tightness in chest, cramps, nausea, malaise, miosis in human volunteers; may limit performance for night operations, aircrews, and tasks involving distance or spatial judgment Significant Level: Reversible miosis, dyspnea, Red blood cell(RBC)-ChE inhibition, single fibre electromyography (SFEMG) changes in human volunteers; may limit performance for night operations, aircrews, and tasks involving distance or spatial judgment Severe Level: Based on GB vapor experimental Sprague-Dawley rat lethality data (LC_{01}, LC_{50}) (see text for more information); (USEPA 2001) Existing (Recommended) IDLH = 0.2 (0.1) mg/m^3
	SIGNIFICANT	0.087 [0.015]	0.035 [0.0060]	0.013 [0.0022]	0.004 [0.00073]		
	SEVERE	0.38 [0.064]	0.13 [0.022]	0.051 [0.0087]	0.02 [0.0029]	Local effects to pupil of the eye; Respiratory system, CNS, gastrointestinal system	

Chemical CAS No.	Air-MEG Health Effect Level	10-Minute mg/m^3 [ppm]	1-Hour mg/m^3 [ppm]	8-Hour mg/m^3 [ppm]	24-Hour mg/m^3 [ppm]	Potential Symptoms and Target Organs/Systems	Notes
GD (Soman) 96-64-0	MINIMAL	0.0035 [0.00046]	0.0014 [0.00018]	0.00050 [0.000065]	0.0002 [0.000022]	See GB for Symptoms.	Based on relative potency from GB (see text for more information); (USEPA 2001) 24-Hour MEG derived from 8-hour AEGL by straight-line extrapolation of 8-hour AEGL Ct (see USEPA 2001 and document text) Existing (Recommended) IDLH = 0.06 (0.05) mg/m^3
	SIGNIFICANT	0.044 [0.0057]	0.018 [0.0022]	0.0065 [0.00085]	0.002 [0.00028]	Local effects to pupil of the eye; Respiratory system, CNS, gastrointestinal system	
	SEVERE	0.38 [0.049]	0.13 [0.017]	0.051 [0.0066]	0.02 [0.0022]		
GF 329-99-7	MINIMAL	0.0035 [0.00049]	0.0014 [0.00020]	0.00050 [0.000070]	0.0002 [0.000023]	See GB for Symptoms.	Based on relative potency from GB (see text for more information); (USEPA 2001) 24-Hour MEG derived from 8-hour AEGL by straight-line extrapolation of 8-hour AEGL Ct (see USEPA 2001 and document text) (Recommended) IDLH = (0.05) mg/m^3 (no previous existing estimate)
	SIGNIFICANT	0.044 [0.0062]	0.018 [0.0024]	0.0065 [0.00091]	0.002 [0.00030]	Local effects to pupil of the eye; respiratory system, CNS, gastrointestinal system	
	SEVERE	0.38 [0.053]	0.13 [0.018]	0.051 [0.0071]	0.02 [0.0024]		

Chemical CAS No.	Air-MEG Health Effect Level	10-Minute mg/m^3 [ppm]	1-Hour mg/m^3 [ppm]	8-Hour mg/m^3 [ppm]	24-Hour mg/m^3 [ppm]	Potential Symptoms and Target Organs/Systems	Notes
Sulfur mustard [HD] 505-60-2	MINIMAL	0.40 [0.06]	0.067 [0.01]	0.008 0.001	0.003 [0.00033]	Delayed development of irritation to eyes, mucous membranes; potent alkylating agent; mutagenic. Conjunctivitis, blindness, edema of eyelids; necrosis of respiratory tract and exposed skin; nausea, vomiting[H]. Eyes, respiratory system, skin	24-Hour MEG estimate derived from 8-hour AEGL by straight-line extrapolation of 8-hour AEGL Ct (see NRC, in press - 2002) Existing (Recommended) GPL = 0.0001 (0.00002) mg/m³ Existing (Recommended) WPL = 0.003 (0.0004) mg/m³
	SIGNIFICANT	0.60 [0.09]	0.10 [0.02]	0.013 0.002	0.004 [0.00067]		
	SEVERE	3.9 [0.59]	2.1 [0.32]	0.27 [0.04]	0.09 [0.013]		

Chemical CAS No.	Air-MEG Health Effect Level	10-Minute mg/m³ [ppm]	1-Hour mg/m³ [ppm]	8-Hour mg/m³ [ppm]	24-Hour mg/m³ [ppm]	Potential Symptoms and Target Organs/Systems	Notes
VX 50782-69-9	MINIMAL	0.00020 [0.000018]	0.000080 [0.0000073]	0.000028 [0.0000026]	0.000009 [0.0000009]	AChE inhibitor; CNS effects: headache, runny nose and nasal congestion, nausea, vomiting, giddiness, anxiety, difficulty in sleeping/thinking, muscle twitching, weakness, abdominal cramps. Local effects to pupil of the eye; Respiratory system, CNS, gastrointestinal system	Minimal and Significant Levels: Derived by relative potency from study of multiple minimal (1) or transient (2) effects in human volunteers exposed to agent GB; may limit performance for night operations, aircrews, and tasks involving distance or spatial judgment Severe Level: Derived by relative potency from study of GB vapor experimental Sprague-Dawley rat lethality data (LC_{01}, LC_{50}) (USEPA 2001). 24-Hour MEG estimate derived from 8-hour AEGL by straight-line extrapolation of 8-hour AEGL Ct (see USEPA 2001 and document text) Existing (Recommended) GPL = 0.000003 (0.0000003) mg/m³ Existing (Recommended) WPL = 0.00001 (0.00001) mg/m³ Existing (Recommended) IDLH = 0.02 (0.01) mg/m³
	SIGNIFICANT	0.0024 [0.00022]	0.00098 [0.000090]	0.00035 [0.000032]	0.0001 [0.000011]		
	SEVERE	0.0096 [0.00088]	0.0033 [0.00030]	0.0013 [0.00012]	0.0004 [0.000040]		

Footnotes on next page.

FOOTNOTES FOR TABLE C-1 – AIR-MEGS FOR CHEMICAL WARFARE AGENTS

AchE: Acetylcholinesterase
AEGL: Acute Exposure Guideline Level
CNS: Central nervous system
Ct: Concentration ? time.
GPL: General population limit
IDLH: Immediately dangerous to life and health
WPL: Worker population limit
RBC – Red blood cell
ppm = part per million
mg/m^3 = milligrams per cubic meter

USEPA – U.S. Environmental Protection Agency. 2001. "National Advisory Committee for Acute Exposure Guideline Levels (AEGLs) for Hazardous Substances; Proposed AEGL Values" *Federal Register* 66 (85): 21940-21964 (2 May 2001).

National Research Council, Committee on Toxicology, Acute Exposure Guideline Levels (AEGLs) for Hazardous Substances, Volume 2; National Academy Press, in press - 2002

TABLE C-2. SHORT-TERM, AIR MILITARY EXPOSURE GUIDELINES (14 DAYS OR LESS)

Chemical CAS No.	1-Hour Air-MEG mg/m^3 [ppm]			8-Hour Air-MEG mg/m^3 [ppm]	14 Day Air-MEG mg/m^3 [ppm]	Potential Symptoms [N]	Target Organs and Systems [N]	Odor Threshold mg/m^3 [ppm] [?]	Notes
	Health Effect Level								
	Minimal	Significant	Severe						
Acetone Cyanohydrin 75-86-5	16.4[C] [4.7]	ND	ND	8 [2]	0.4 [0.1]	Irritation eyes, skin, respiratory system; dizziness, weakness, headache, confusion, convulsions; liver, kidney injury; pulmonary edema, asphyxia.	Eyes, skin, rs, CNS, CVS, liver, kidneys, GI tract	NA	Treatment of over exposure is for cyanide poisoning.
Acrolein 107-02-8	0.07 [0.03]	0.23 [0.1]	3.2 [1.4]	0.07 [0.03]	0.023 [0.01]	Irritation eyes, skin, mucous membrane; decreased pulmonary function; delayed pulmonary edema; chronic respiratory disease.	Eyes, skin, RS, heart	[0.022 – 1.8]	Pungent odor; concentrations of 0.06 ppm for 5 min caused irritation in humans.
Acrylonitrile 107-13-1	22 [10]	76 [35]	163 [75]	4.4 [2]	0.22 [0.10]	Irritation eyes, skin; asphyxia; headache; sneezing; nausea, vomiting; weakness, lightheadedness; skin vesiculation; scaling dermatitis.	Eyes, skin, CVS, liver, kidneys, CNS	[17]	Potential occupational carcinogen.
Aldrin 309-00-2	ND	ND	25	0.25[S] [0.02]	0.006[S] [0.0004]	Headache, dizziness; nausea, vomiting, malaise; limb jerks; convulsions; coma; hematuria: azotemia.	CNS, liver, kidneys, skin	0.25	Dermal exposures may contribute to total dose; potential occupational carcinogen.
Allyl alcohol 107-18-6	4.4 [1.8]	18.3 [7.7]	48 [20]	4.4[S] [1.8]	0.012[S] [0.05]	Eye irritation, tissue damage; irritation upper respiratory system, skin; pulmonary edema.	Eyes, skin, RS	[1.4 – 2.1]	Pungent, mustard-like odor. Dermal exposures may contribute to total dose.

Chemical CAS No.	1-Hour Air-MEG mg/m^3 [ppm] Health Effect Level Minimal	Significant	Severe	8-Hour Air-MEG mg/m^3 [ppm]	14 Day Air-MEG mg/m^3 [ppm]	Potential Symptoms [N]	Target Organs [N] and Systems	Odor? Threshold mg/m^3 [ppm]	Notes
Ammonia 7664-41-7	17 [25]	77 [110]	766 [1100]	17 [25]	0.35 [0.5]	Irritation eyes, nose, throat; difficulty breathing, bronchospasm; pulmonary edema; pink frothy sputum; skin burns.	Eyes, skin, RS	[17]	Pungent, suffocating odor.
Arsenic trichloride 7784-34-1	ND	ND	ND	0.01* [0.003]	0.01* [0.003]	Irritation of nose and throat[R].	Eyes, RS	NA	1-14 day value based on inorganic arsenic. *Measured as arsenic. CHID under development.
Arsine 7784-42-1	NA	0.54 [0.17]	1.6 [0.5]	0.17 [0.05]	0.004 [0.0012]	Headache, malaise; difficulty breathing; nausea, vomiting; bronze skin; hematuria; jaundice.	Blood, liver, kidneys	[0.5]	Disagreeable, garlic-like odor.
Benzene 71-43-2	160 [50]	479 [150]	3195 [1000]	1.6 (0.5)	0.16 [0.05]	Irritation eyes, skin, nose, respiratory system; giddiness; headache, nausea, staggered gait; fatigue, loss of appetite, lassitude (weakness, exhaustion); dermatitis; bone marrow depressant/depression.	Eyes, skin, RS, blood, CNS, bone	[34 119]	Aromatic odor; chronic exposures to low concentrations causes bone marrow depression; known carcinogen. CHID under development.
Boron tribromide 10294-33-4	10[C] [1]	ND	ND	10[C] [1]	10[C] [1]	Irritation eyes, skin, respiratory system; dyspnea, pulmonary edema.	Eyes, skin, RS	NA	
Boron trifluoride 7637-07-2	2 [0.73]	30 [11]	100 [36]	2 [0.73]	2 [0.73]	Irritation eyes, skin, nose, respiratory system; epistaxis (nosebleed); eye, skin burns; pneumonia; kidney damage.	Eyes, skin, RS, kidneys	NA	Low 1-hr value based on NOAEL; 6-hr exposures to rats at 2.2 ppm 6

Chemical CAS No.	1-Hour Air-MEG mg/m^3 [ppm] Health Effect Level Minimal	Significant	Severe	8-Hour Air-MEG mg/m^3 [ppm]	14 Day Air-MEG mg/m^3 [ppm]	Potential Symptoms [N]	Target Organs [N] and Systems	Odor? Threshold mg/m^3 [ppm]	Notes
									hrs/d for 3 months produced slight signs of irritation.
Bromine 7726-95-6	0.16 [0.024]	1.6 [0.24]	56 [8.5]	0.063 [0.0095]	0.063 [0.0095]	Dizziness, headache; lacrimation, epistaxis; cough, pulmonary edema, pneumonia; abdominal pain, diarrhea; measle-like eruptions; eye, skin burns.	RS, eyes, CNS, skin	[0.05]	Suffocating odor; concentrations above 10 ppm causes severe upper respiratory irritation; 1.7 – 3.5 ppm produces severe choking; 30 ppm would be fatal in a short duration.
Bromine pentafluoride 7789-30-2	ND	ND	ND	0.7 [0.1]	0.7 [0.1]	Irritation eyes, skin, respiratory system; corneal necrosis; skin burns; difficulty breathing, pulmonary edema; liver, kidney injury.	Eyes, skin, RS, liver, kidneys	NA	Potential sensitizer.
Butyl isocyanate (n-) 111-36-4	0.04 [0.01]	0.2 [0.05]	4.1 [1]	ND	ND	Skin irritation, eczema, conjunctivitis [H].	Skin and eyes[H]	NA	Concentrations of 0.1 – 1 ppm produce irritation to the respiratory tract and mucous membranes.
Carbon disulfide 75-15-0	3 [1]	156 [50]	1557 [500]	3[S] [1]	0.76[S] [0.24]	Dizziness, headache, nervousness, loss of appetite, polyneuropathy, ocular changes, coronary heart disease, gastritis, kidney, liver injury, dermatitis, reproductive effects.	CNS, PNS, CVS, eyes, kidneys, liver, skin, REPR	[0.11]	Dermal exposures may contribute to total dose; sweet, ether-like odor.

Chemical CAS No.	1-Hour Air-MEG mg/m^3 [ppm] Health Effect Level Minimal	Significant	Severe	8-Hour Air-MEG mg/m^3 [ppm]	14 Day Air-MEG mg/m^3 [ppm]	Potential Symptoms [N]	Target Organs [N] and Systems	Odor Threshold mg/m^3 [ppm]	Notes
Carbon monoxide 630-08-0	229 [200]	286 [350]	572 [500]	28 [25]	0.70 [0.61]	Headache, rapid breathing, nausea, weakness, dizziness, confusion, hallucinations; cyanosis; depressant/depression S-T segment of electro-cardiogram, angina, syncope.	CVS, lungs, blood, CNS	NA	
Carbon tetrachloride 56-23-5	75 [12]	428 [68]	1070 [170]	32.5 [5.2]	1.3 [0.2]	Irritation eyes, skin; CNS depressant/depression; nausea, vomiting; liver, kidney injury; drowsiness, dizziness, incoordination.	CNS, eyes, lungs, liver, kidneys, skin.	[140 584]	Aromatic, ether-like odor; potential occupational carcinogen.
Carbonyl fluoride 353-50-4	ND	ND	ND	5 [2]	[0.05] 0.13	Irritation eyes, skin, mucous membrane, respiratory system; eye, skin burns; excessive tearing; cough, pulmonary edema, difficulty breathing.	Eyes, skin, RS, bone	NA	
Chlorine 7782-50-5	2.9 [1]	5.8 [2]	64 [22]	1.5 [0.5]	0.29 [0.1]	Burning of eyes, nose, mouth; excessive tearing, rhinorrhea; coughing, choking, substernal pain; nausea, vomiting; hypoxemia; dermatitis.	CNS, eyes, lungs, liver, kidneys, skin	[0.02 – 3.4]	Pungent, disagreeable odor; a concentration of 34 – 51 ppm has been reported to be fatal in 1 – 1.5 hours.
Chlorine trifluoride 7790-91-2	1.3 [0.35]	11.7 [3.1]	53 [14]	0.15 [0.04]	0.15 [0.04]	Respiratory irritation; in animals: excessive tearing, corneal ulcer; pulmonary edema.	Skin, eyes, RS	NA	ACGIH ceiling value - 0.1 ppm (0.4 mg/m^3)
Chloro-acetaldehyde 107-20-0	3.2[C] [1]	71 [22]	144 [45]	3.2[C] [1]	3.2[C] [1]	Irritation skin, eyes, mucous membrane; skin burns; eye damage; pulmonary edema; skin, respiratory system	Eyes, skin, RS	NA	Volunteers found that concentrations of 45 ppm were very disagreeable

Chemical CAS No.	1-Hour Air-MEG mg/m^3 [ppm] Health Effect Level Minimal	Significant	Severe	8-Hour Air-MEG mg/m^3 [ppm]	14 Day Air-MEG mg/m^3 [ppm]	Potential Symptoms [N]	Target Organs [N] and Systems	Odor [?] Threshold mg/m^3 [ppm]	Notes
						sensitization.			and conjunctival irritation was noted.
Chloroacetone 78-95-5	3.8[C] [1]	ND	ND	3.8[C] [1]	3.8[C] [1]	Excessive tearing, irritation skin and respiratory tract, pulmonary edema[H].	Eyes, skin, RS	NA	Concentration of 605 ppm is lethal after a 10 minute exposure and 26 ppm is intolerable after a 1 minute exposure.
Chloroaceto-phenone [CN] 532-27-4	ND	ND	15	0.32 [0.05]	0.32 [0.05]	Excessive tearing, irritation of the skin, rashes in tender skin areas of the armpits, knees, elbows, area of the crotch and buttocks[T].	Skin, eyes[T]	[0.016]	Floral to sharp, irritating odor with increasing concentration; concentration of 31 mg/m^3 is intolerable after 3 minutes.
Chloroacetyl chloride 79-04-9	0.23 [0.05]	2.3 [0.5]	46 [10]	0.23[S] [0.05]	0.23[S] [0.05]	Irritation eyes, skin, respiratory system; eye, skin burns; cough, wheezing, difficulty breathing; excessive tearing.	Eyes, skin, RS	NA	Dermal exposures may contribute to total dose.
Chlorobenzyli-denemalonitrile o- [CS] 2698-41-1	0.39[C] [0.05]	ND	2 [0.26]	0.39[C] [0.05]	0.39[C] [0.05]	Extremely irritating to the nose and throat with immediate lacrimatory effects; nausea and vomiting; shortness of breath, burning of the skin especially effecting the eyes, nose, mouth, and tender areas around the knees, elbows, crotch, and buttocks[T].	Eyes, skin, CNS, RS[T]	NA	Peppery odor; incapacitating concentration range from 12 – 20 mg/m^3 after 20 seconds of exposure.

Chemical CAS No.	1-Hour Air-MEG mg/m^3 [ppm] Health Effect Level Minimal	Significant	Severe	8-Hour Air-MEG mg/m^3 [ppm]	14 Day Air-MEG mg/m^3 [ppm]	Potential Symptoms [N]	Target Organs [N] and Systems	Odor? Threshold mg/m^3 [ppm]	Notes
Chloroform 67-66-3	NA	430 [88]	3174 [650]	48 [10]	0.5 [0.1]	Irritation eyes, skin; dizziness, mental dullness, nausea, confusion; headache, fatigue; anesthesia; enlarged liver.	Liver, kidneys, heart, eyes, skin, CNS.	[133-276]	Pleasant, ether-like odor; potential occupational carcinogen; disorientation occurs at concentrations exceeding 1000 ppm.
Crotonaldehyde 4170-30-3	0.54 [0.19]	12.6 [4.4]	40 [14]	0.54[S] [0.19]	0.54[S] [0.19]	Irritation of the eyes and respiratory system; in animals: difficulty breathing, pulmonary edema, skin irritation.	Eyes, skin, RS	[0.11]	Dermal exposures may contribute to total dose; pungent odor. 0.3 ppm[C]
Cyanogen 460-19-5	22 [20]	78 [71]	166 [150]	20 [10]	0.51 [0.24]	Irritation eyes, nose, upper respiratory system; excessive tearing; cherry red lips, bradycardia; headache, vertigo, convulsions; dizziness, loss of appetite, weight loss; smell of bitter almonds on breath.	Eyes, RS, CNS, CVS, blood	[235]	Based on cyanide. Inhibits cells ability to utilize oxygen; Persons with kidney/ respiratory (including asthma), skin or thyroid conditions at greater risk.
Diborane 19287-45-7	0.34 [0.3]	1.13 [1]	4.2 [3.7]	0.1 [0.1]	0.0024 [0.0024]	Chest tightness, precordial pain, shortness breathing, cough, nausea, headache, dizziness, fever, fatigue, weakness, tremor; liver, kidney damage, pulmonary edema and hemorrhage.	RS, CNS, liver, kidneys	[2.5]	Repulsive, sickly sweet odor.

Chemical CAS No.	1-Hour Air-MEG mg/m^3 [ppm] Health Effect Level Minimal	Significant	Severe	8-Hour Air-MEG mg/m^3 [ppm]	14 Day Air-MEG mg/m^3 [ppm]	Potential Symptoms [N]	Target Organs [N] and Systems	Odor Threshold mg/m^3 [ppm]	Notes
Dichloroethane (1,1-) 75-34-3	ND	ND	12,144 [3000]	400 [100]	9.8 [2.4]	Irritation skin; CNS depressant/ depression; liver, kidney, lung damage.	Skin, liver, kidneys, lungs, CNS	[100 – 200]	Odor threshold range broad: care should be used when attempting to estimate exposure from odor perception.
Dieldrin 60-57-1	0.75	1.25	50	0.25[S] [0.02]	0.006[S] [0.0004]	Headache, dizziness; nausea, vomiting, malaise, sweating; limb jerks; convulsions; coma; in animals: liver, kidney damage.	CNS, liver, kidneys, skin	NA	Dermal exposures may contribute to total dose. Potential occupational carcinogen.
Diesel fuel smoke	8	80	ND	5	5	Inflammation of lung, irritation of respiratory tract, congestion in nasal turbinate, bronchopneumonia, bronchitis, pulmonary congestion with edema and hemorrhage[M].	Lung, RS[M]	NA	
Diketene 674-82-8	3.4 [1]	17 [5]	69 [20]	NA	NA	Eye, skin, and respiratory tract irritation[H].	Eyes, skin, RS[H]	NA	
Dimethyl sulfate 77-78-1	1.5 [0.3]	5.2 [1]	36 [7]	0.5[S] [0.1]	0.0012[S] [0.0024]	Irritation eyes, nose; headache, giddiness; conjunctivitis; photophobia, edema; dysphonia, dysphagia, productive cough; chest pain; difficulty breathing, cyanosis; vomiting, diarrhea.	Eyes, skin, RS, liver, kidneys, CNS	NA	Dermal exposure may contribute to total dose.
Endrin 72-20-8	0.1[S] [0.008]	0.3 [0.024]	2 [0.16]	0.1[S] [0.008]	0.01[S] [0.00016]	Headache, dizziness; abdominal discomfort, nausea, vomiting, stupor, aggressiveness, confusion; lethargy (drowsiness or	CNS, liver	0.28	Dermal exposures may contribute to total dose – skin absorption should be avoided.

Chemical CAS No.	1-Hour Air-MEG mg/m^3 [ppm] Health Effect Level Minimal	Significant	Severe	8-Hour Air-MEG mg/m^3 [ppm]	14 Day Air-MEG mg/m^3 [ppm]	Potential Symptoms [N]	Target Organs [N] and Systems	Odor? Threshold mg/m^3 [ppm]	Notes
						indifference), weakness; epileptiform convulsions; insomnia; loss of appetite; in animals: liver damage.			Primary route of toxicity is through ingestion of contaminated media; will metabolize quickly.
Ethyl benzene 100-41-4	542 [125]	4342 [1000]	8684-21710 [2000-5000]	435 [100]	10.5 [2.4]	Irritation eyes, skin, mucous membrane; headache; dermatitis; narcosis, coma.	Eyes, skin, RS, CNS	[0.09 – 0.60]	Most severe irritant of benzene series; strong eye irritation/tear/with tolerance developing levels below 1000 ppm; at 2000 ppm intolerable eye effects. Aromatic odor.
Ethylenimine 151-56-4	2.64 [1.5]	8.1 [4.6]	17.4 [9.9]	0.92[S] [0.5]	0.022[S] [0.012]	Irritation eyes, skin, nose, throat; nausea, vomiting; headache, dizziness; pulmonary edema; liver, kidney damage; eye burns; skin sensitization.	Eyes, skin, RS, liver, kidneys	NA	Dermal exposures may contribute to total dose; ammonia-like odor.
Ethylene oxide 75-21-8	14 [7.5]	81 [45]	360 [200]	1.8 [1]	0.04 [0.02]	Irritation eyes, skin, nose, throat; peculiar taste; headache, nausea; vomiting, diarrhea; difficulty breathing, cyanosis, pulmonary edema; incoordination; EKG abnormalities.	Eyes, skin, RS, liver, CNS, blood, kidneys, REPR	[425]	Based on soluble tungsten; sweet olefininc odor; concentrations > 1 hr, at 2000 ppm may be fatal.
Fluorine 7782-41-4	3.1 [2]	7.8 [5]	20.2 [13]	1.6 [1]	1.6 [1]	Irritation eyes, nose, respiratory system; laryngeal	Eyes, skin, RS, liver, kidneys	[0.14]	Low value based on odor; repeated

Chemical CAS No.	1-Hour Air-MEG mg/m^3 [ppm]			8-Hour Air-MEG mg/m^3 [ppm]	14 Day Air-MEG mg/m^3 [ppm]	Potential Symptoms [N]	Target Organs [N] and Systems	Odor Threshold mg/m^3 [ppm]	Notes
	Health Effect Level								
	Minimal	Significant	Severe						
						spasm, bronchitis spasm; pulmonary edema; eye, skin burns; liver and kidney damage in animals.			exposure to 10 ppm was reported to be well-tolerated in workers; concentrations of 25 ppm have been tolerated briefly, yet two volunteers developed sore throats and chest pains that lasted 6 hrs; 50 ppm could not be tolerated.
Fog oil smoke	9	90	ND	5	5	Mild erythema, inflammation, dermatitis, acne, eczema, and contact sensitivity; pneumonia, cough, and phlegm[M].	Skin, lungs, RS[M]	NA	
Formaldehyde 50-00-0	1.2 [1]	12.3 [10]	31 [25]	0.37[C] [0.3]	0.37[C] [0.3]	Respiratory system irritation; excessive tearing; cough, bronchitis spasm.	Eyes, RS	[0.83]	Pungent, suffocating odor.
GA (Tabun) 77-81-6	See Table C-1								
GB (Sarin) 107-44-8	See Table C-1								
GD (Soman) 96-64-0	See Table C-1								

Chemical CAS No.	1-Hour Air-MEG mg/m³ [ppm] Health Effect Level Minimal	Significant	Severe	8-Hour Air-MEG mg/m³ [ppm]	14 Day Air-MEG mg/m³ [ppm]	Potential Symptoms [N]	Target Organs [N] and Systems	Odor Threshold mg/m³ [ppm]	Notes
GF 329-99-7	See Table C-1								
Hexachloro-butadiene 87-68-3	32 [3]	107 [10]	320 [30]	0.24[S] [0.02]	0.005[S] [0.0005]	In animals: irritation eyes, skin, respiratory system; kidney damage.	Eyes, skin, RS, kidneys	[1.1]	Dermal exposures may contribute to total dose; turpentine-like odor; potential occupational carcinogen; concentrations of 23 ppm (245 mg/m³) produced strong odors; 1 ppm (10 mg/m³), faint odor.
Hexachloro-cyclopentadiene 77-47-4	0.1 [0.01]	0.35 [0.03]	1.6 [0.15]	0.1 [0.01]	0.1 [0.01]	Irritation eyes, skin, respiratory system; excessive tearing; sneezing, cough, difficulty breathing, salivation, pulmonary edema; nausea, vomiting, diarrhea.	Eyes, skin, RS, liver, kidneys	[0.03]	Strong irritant with concentration threshold at 0.1 mg/m³ – at this point no longer duration dependant. Pungent, unpleasant odor.
Hexachloroethane (smoke) 67-72-1	0.3	3	ND	0.2	0.2	Acute respiratory distress syndrome, edema, difficulty breathing, chest constriction, retrosternal pain, hoarseness, cough, lacrimation	RS, lungs, eyes [M]	NA	Symptoms and target organ based on exposure to $ZnCl_2$, (zinc chloride) a

Chemical CAS No.	1-Hour Air-MEG mg/m³ [ppm] Health Effect Level Minimal	Significant	Severe	8-Hour Air-MEG mg/m³ [ppm]	14 Day Air-MEG mg/m³ [ppm]	Potential Symptoms [N]	Target Organs [N] and Systems	Odor? Threshold mg/m³ [ppm]	Notes
						expectoration, irritation of the nose, throat, and chest; nausea[M].			component released when smoke bomb is ignited.
Hexane 110-54-3	528 [150]	880 [250]	3872 [1100]	180[S] [50]	4.3[S] [1.2]	Irritation eyes, nose; lightheadedness; nausea, headache; peripheral neuropathy: numbness extremities, muscle weakness; dermatitis; giddiness; chemical pneumonia (aspiration liquid).	Eyes, skin, RS, CNS, PNS	[130]	Dermal exposures may contribute to total dose.
Hydrazine 302-01-2	0.13 [0.1]	17 [13]	46 [35]	0.13 [0.1]	0.013 [0.01]	Irritation eyes, skin, nose, throat; temporary blindness; dizziness, nausea; dermatitis; eye, skin burns; in animals: bronchitis, pulmonary edema; liver, kidney damage; convulsions.	Eyes, skin, RS, CNS, liver, kidneys	[3 - 4]	Potential carcinogen.
Hydrogen bromide 10035-10-6	9.9[C] [3]	19.8 [6]	99 [30]	9.9[C] [3]	9.9[C] [3]	Irritation eyes, skin, nose, throat.	Eyes, skin, RS	[2]	Strong irritant with concentration threshold at 9.9 mg/m³ – at this point no longer duration dependant. Sharp irritating odor; skin burns.
Hydrogen chloride 7647-01-0	2.7 [1.8]	33 [22]	155 [104]	2.7 [1.8]	2.7 [1.8]	Irritation nose, throat, larynx; cough, choking; dermatitis.	Eyes, skin, RS	[0.77]	Asthmatics may experience adverse effects above 3 ppm; concentrations of

Chemical CAS No.	1-Hour Air-MEG mg/m^3 [ppm] Health Effect Level Minimal	Significant	Severe	8-Hour Air-MEG mg/m^3 [ppm]	14 Day Air-MEG mg/m^3 [ppm]	Potential Symptoms [N]	Target Organs [N] and Systems	Odor Threshold mg/m^3 [ppm]	Notes
									35 ppm caused throat irritation; 50 – 100 ppm are barely tolerable.
Hydrogen cyanide 74-90-8	2.2 [2]	7.8 [7.1]	16.6 [15]	1.1[S] [1]	0.11[S] [0.11]	Asphyxia; weakness, headache, confusion; nausea, vomiting; increased rate and depth of respiration or respiration slow and gasping; thyroid, blood changes.	CNS, CVS, thyroid, blood	NA	Dermal exposures may contribute to total dose; sweetish, almond-like odor; concentrations of 45 – 54 ppm may be tolerable for 0.5 – 1.0 hr; 110 – 135 ppm may be fatal after 0.5 – 1.0 hr or later.
Hydrogen fluoride 7664-39-3	0.82 [1]	19.6 [24]	36 [44]	0.41 [0.5]	0.41 [0.5]	Irritation eyes, skin, nose, throat; pulmonary edema; eye, skin burns; rhinitis; bronchitis; bone changes.	Eyes, skin, RS, bones	[0.04]	Exposures of 2.7-4.7 ppm produced very slight irritation and was tolerated 6hrs/d for several days; concentrations of 50 ppm for 30 – 60 min may be fatal. volunteers tolerated 4.7 ppm for 6-hrs/ day for 10 – 50 days.

Chemical CAS No.	1-Hour Air-MEG mg/m^3 [ppm] Health Effect Level Minimal	Significant	Severe	8-Hour Air-MEG mg/m^3 [ppm]	14 Day Air-MEG mg/m^3 [ppm]	Potential Symptoms [N]	Target Organs [N] and Systems	Odor Threshold mg/m^3 [ppm]	Notes
Hydrogen selenide 7783-07-5	ND	ND	3.3 [1]	0.2 [0.05]	0.2 [0.05]	Irritation eyes, nose, throat; nausea, vomiting, diarrhea; metallic taste, garlic breathing; dizziness, lassitude, fatigue.	Eyes, RS, liver	NA	*Measured as selenium.
Hydrogen sulfide 7783-06-4	0.23 [0.17]	39 [28]	70 [50]	0.15 [0.11]	0.15 [0.11]	Irritation eyes, apnea, coma, convulsions; conjunctivitis, eye pain, lacrimation photophobia (abnormal visual intolerance to light), corneal vesiculation; dizziness, headache, fatigue, insomnia; gastrointestinal disturbance.	Eyes, RS, CNS	[0.001 – 0.13]	Rotten egg odor strong at concentrations above 0.1 ppm; concentrations of 170 to 300 ppm are the maximum tolerated concentrations for 1-hr without serious consequences; olfactory fatigue occurs at 100 ppm.
Iron pentacarbonyl 13463-40-6	ND	1.5 [0.19]	4.6 [0.58]	0.8 [0.1]	0.02 [0.0024]	Irritation eyes, mucous membrane, respiratory system; headache, dizziness, nausea, vomiting; fever, cyanosis, difficulty breathing; liver, kidney, lung injury; degenerative changes in CNS.	Eyes, RS, CNS, liver, kidneys	NA	* Measured as iron.
Lewisite 541-25-3	0.003[C] [0.00035]	ND	ND	0.003[C] [0.00035]	0.003[C] [0.00035]	Immediate pain in the eyes, resulting in profuse tearing and blepharospasm; pulmonary irritant, erythema, pulmonary edema[H].	Eyes, RS[H]	NA	See Table C-1
Lindane 58-89-9	1.5 [0.126]	50 [4.2]	50 [4.2]	0.5[S] [0.04]	0.012[S] [0.001]	Irritation eyes, skin, nose, throat; headache; nausea;	Eyes, skin, RS, CNS, blood, liver,	NA	Dermal exposures may contribute to

Chemical CAS No.	1-Hour Air-MEG mg/m³ [ppm] Health Effect Level: Minimal	Significant	Severe	8-Hour Air-MEG mg/m³ [ppm]	14 Day Air-MEG mg/m³ [ppm]	Potential Symptoms [N]	Target Organs [N] and Systems	Odor [?] Threshold mg/m³ [ppm]	Notes
						convulsions; respiratory difficulty; cyanosis; aplastic anemia; muscle spasm; in animals: liver, kidney damage.	kidneys		total dose; 2 & 3 values based on oral data.
Methyl bromide 74-83-9	58.3 [15]	195 [50]	777 [200]	4[S] [1]	0.09[S] [0.024]	Irritation eyes, skin, muscle weakness, visual disturbance, dizziness; nausea, vomiting, headache; malaise; hand tremor; convulsions; difficulty breathing; skin vesiculation.	Eyes, skin, RS, CNS	NA	Dermal exposures may contribute to total dose.
Methylene chloride 75-09-2	695 [200]	2600 [750]	13,880 [4000]	175 [50]	2.1 [0.6]	Irritation eyes, skin; fatigue, weakness, somnolence (sleepiness, unnatural drowsiness), lightheadedness; numbness, limbs tingle, nausea.	Eyes, skin, CVS, CNS	[160]	Sweet, chloroform-like odor; potential occupational carcinogen.
Methyl hydrazine 60-34-4	ND	1.9 [1]	5.7 [3]	0.02[S] [0.01]	0.0005[S] [0.00024]	Irritation eyes, skin, respiratory system; vomiting, diarrhea, tremor, ataxia; anoxia, cyanosis; convulsions.	Eyes, skin, RS, CNS, liver, blood, CVS	[1.7]	Dermal exposures may contribute to total dose.
Methyl isocyanate 624-83-9	0.06 [0.025]	0.16 [0.067]	0.47 [0.2]	0.05[S] [0.02]	0.05[S] [0.02]	Irritation eyes, skin, nose, throat; respiratory sensitization, cough, pulmonary secretions, chest pain, difficulty breathing; asthma; eye, skin damage.	Eyes, skin, RS	[2.1]	Dermal exposures may contribute to total dose; sharp, pungent odor.
Methyl mercaptan 74-93-1	1 [0.5]	9.7 [5]	45 [23]	1 [0.5]	0.024 [0.012]	Irritation eyes, skin, respiratory system; narcosis; cyanosis; convulsions.	Eyes, skin, RS, CNS, blood	[0.0016]	Odor of rotten cabbage significant at concentrations above 0.005 ppm; odor fatigue occurs with time.

Chemical CAS No.	1-Hour Air-MEG mg/m^3 [ppm] Health Effect Level			8-Hour Air-MEG mg/m^3 [ppm]	14 Day Air-MEG mg/m^3 [ppm]	Potential Symptoms [N]	Target Organs and Systems [N]	Odor Threshold mg/m^3 [ppm] [?]	Notes
	Minimal	Significant	Severe						
Nitric acid 7697-37-2	1.3 [0.5]	10 [4]	57 [22]	1.3 [0.5]	1.3 [0.5]	Irritation eyes, skin, mucous membrane; delayed pulmonary edema, pneumonititis, bronchitis; dental erosion.	Eyes, skin, RS	[0.3]	
Nitric oxide 10102-43-9	0.61* [0.5]	15* [12]	25* [20]	0.61* [0.5]	0.61* [0.5]	Irritation eyes, wet skin, nose, throat; drowsiness, unconsciousness; methemoglobinemia.	Eyes, skin, RS, blood, CNS	[0.3]	*Values for NO are based on NO_2 toxicity since NO converts to NO_2 in the atmosphere. No hazard associated with short-term exposure to 80 ppm.
Nitrogen dioxide 10102-44-0	0.94 [0.5]	23 [12]	38 [20]	0.94 [0.5]	0.94 [0.5]	Irritation eyes, nose, throat, cough, mucoid frothy sputum, decreased pulmonary function, difficulty breathing; chest pain; pulmonary edema, cyanosis, rapid breathing, tachycardia.	Eyes, RS, CVS	[1.06]	CHID is under development.
Paraquat 4685-14-7	0.15 [0.024]	1.0 [0.16]	*	0.1 [0.016]	0.01 [0.0016]	Irritation eyes, skin, nose, throat, respiratory system; epistaxis; dermatitis; fingernail damage; irritation gastrointestinal tract; heart, liver, kidney damage.	Eyes, skin, RS, heart, liver, kidneys, GI tract	NA	* Must be aerosolized to inhale –only brief inhalation exposures expected; severe effects toxicity data is limited to primary route of ingestion - MEG toxicity based on

Chemical CAS No.	1-Hour Air-MEG mg/m³ [ppm] Health Effect Level Minimal	 Significant	 Severe	8-Hour Air-MEG mg/m³ [ppm]	14 Day Air-MEG mg/m³ [ppm]	Potential Symptoms [N]	Target Organs [N] and Systems	Odor? Threshold mg/m³ [ppm]	Notes
									particle size (see RD 230). 1.5 mg/m³ = IDLH; 0.5= TWA for total dust; 0.1 TWA for respirable fraction.
Parathion 56-38-2	0.3 [0.024]	2 [0.16]	10 [0.8]	0.1 [0.008]	0.0024 [0.0002]	Irritation eyes, skin, respiratory system; miosis; rhinorrhea; headache; chest tightness, wheezing, laryngeal spasm, salivation, cyanosis; anorexia, nausea, vomiting, abdominal cramps, diarrhea; sweating; muscle fasiculation, weakness, paralysis; giddiness, confusion, ataxia; convulsions, coma; low blood pressure; cardiac irregular/irregularities.	Eyes, skin, RS, CNS, CVS, blood ChE Inh	[0.04]	
Perchloro-methyl mercaptan 594-42-3	0.11 [0.014]	0.27 [0.035]	2.3 [0.3]	0.05 [0.006]	0.05 [0.006]	Irritation eyes, skin, nose, throat; lacrimation; cough, difficulty breathing, deep breathing pain, coarse rales; vomiting; pallor, tachycardia; acidosis; anuria; liver, kidney damage.	Eyes, skin, RS, liver, kidneys	[0.001]	
Phosgene 75-44-5	0.4 [0.1]	1.2 [0.3]	3.0 [0.75]	0.4 [0.1]	0.04 [0.01]	Irritation eyes; dry burning throat; vomiting; cough, foamy sputum, difficulty breathing, chest pain, cyanosis.	Eyes, skin, respiratory system	[0.5]	Lethality may occur at lower concentrations (5 ppm) due to pulmonary edema.
Phosphine 7803-51-2	NA	0.42 [0.3]	1.5 [1.1]	0.4 [0.3]	0.01 [0.0073]	Nausea, vomiting, abdominal pain, diarrhea; thirst; chest	CNS, RS	[0.9]	Disagreeable odor of rotten fish or

Chemical CAS No.	1-Hour Air-MEG mg/m³ [ppm] Health Effect Level: Minimal	Significant	Severe	8-Hour Air-MEG mg/m³ [ppm]	14 Day Air-MEG mg/m³ [ppm]	Potential Symptoms [N]	Target Organs and Systems [N]	Odor Threshold mg/m³ [ppm] [?]	Notes
						tightness, difficulty breathing, muscle pain, chills; stupor or syncope; pulmonary edema.			garlic; concentrations up to 35 ppm have caused diarrhea, nausea, vomiting, cough, headache, and dizziness.
White phosphorus (yellow) 7723-14-0	0.3 [0.06]	3 [0.59]	5 [0.99]	0.1 [0.02]	0.0024 [0.0005]	Irritation eyes, respiratory tract; eyes, skin burns; abdominal pain, nausea, jaundice; anemia; cachexia; dental pain, salivation, jaw pain, swelling.	Eyes, skin, RS, liver, kidneys, blood, bone	NA	
Phosphorus oxychloride 10025-87-3	ND	ND	5.3 [0.85]	0.6 [0.1]	0.015 [0.002]	Irritation eyes, skin, respiratory system; eye, skin burns; difficulty breathing, cough, pulmonary edema; dizziness, headache, weakness; abdominal pain, nausea, vomiting; nephritis.	Eyes, skin, RS, CNS, kidneys	NA	
Phosphorus trichloride 7719-12-2	ND	ND	4.9 [0.87]	1.5 [0.27]	1.5 [0.27]	Irritation eyes, skin, nose, throat; pulmonary edema; eye, skin burns.	Eyes, skin, RS	NA	Concentrations of 1.8 – 27 ppm have been reported to produce burning of the eyes and throat, and mild bronchitis within 2 – 6 hrs after exposure.
Red phosphorus smoke	1	10	1000	1	1	Irritation eyes, respiratory tract; eye, skin burns; abdominal pain, nausea, jaundice; anemia; cachexia;	Eyes, skin, RS, liver, kidneys, bone, blood	NA	

Chemical CAS No.	1-Hour Air-MEG mg/m³ [ppm] Health Effect Level Minimal	Significant	Severe	8-Hour Air-MEG mg/m³ [ppm]	14 Day Air-MEG mg/m³ [ppm]	Potential Symptoms [N]	Target Organs and Systems [N]	Odor Threshold mg/m³ [ppm] [?]	Notes
						dental pain, salivation, jaw pain, swelling.			
Selenium hexa-fluoride 7783-79-1	1.2 [0.15]	2 [0.25]	16 [2]	0.4 [0.05]	0.4 [0.05]	Pulmonary irritation, edema.	RS		*Measured as selenium.
Stibine 7803-52-3	ND	2.6 [0.5]	7.7 [1.5]	0.5 [0.1]	0.5 [0.1]	Headache, weakness; nausea, abdominal pain; lumbar pain, hemoglobinuria, hematuria, hemolytic anemia; jaundice; pulmonary irritation.	Blood, liver, kidneys, RS	NA	
Sulfur dioxide 7446-09-5	ND	8 [3]	39 [15]	5 [2]	2.6 [1]	Irritation eyes, nose, throat; rhinorrhea (discharge of thin nasal mucus); choking, cough; reflex bronchoconstriction.	Eyes, skin, RS	[1.1]	Metallic taste, sharp. Asthmatics may experience reduced airway resistance above 0.3 ppm. CHID under development.
Sulfur mustard [HD] 505-60-2	See Table C-1								
Sulfuric acid 7664-93-9	2 [0.5]	10 [2.5]	30 [7.5]	1 [0.25]	1 [0.25]	Severe lung damage; loss of vision; corrosion of mucous membranes; nausea, vomiting.	RS	1	Carcinogen; lung.
Sulfuryl fluoride 2699-79-8	ND	ND	835 [200]	20 [5]	0.5 [0.12]	Conjunctivitis, rhinitis, pharyngitis, paresthesia; liquid; frostbite: in animals: narcosis, tremor, convulsions; pulmonary edema; kidney injury.	Eyes, skin, RS, CNS, kidneys	NA	
Tellurium hexafluoride 7783-80-4	0.6 [0.06]	10 [1]	**	0.2 [0.02]	0.2 [0.02]	Results in bluish black coloration of webs of fingers/streaks on face;	RS	NA	Measured as tellurium. Suggestion of

Chemical CAS No.	1-Hour Air-MEG mg/m³ [ppm] Health Effect Level: Minimal	Significant	Severe	8-Hour Air-MEG mg/m³ [ppm]	14 Day Air-MEG mg/m³ [ppm]	Potential Symptoms [N]	Target Organs [N] and Systems	Odor Threshold mg/m³ [ppm]	Notes
						possible smell of garlic from sweat/breathing; headache; difficulty breathing; in animals: pulmonary edema			tolerance – mild effects may dissipate after prolonged exposure. ** Not clear at what level human fatalities or true severe effects would occur (just greater than 1 ppm)
Tetrachloro-ethane (1,1,2,2-) 79-34-5	20.6 [3]	34.3 [5]	686 [100]	7 [1]	0.2 [0.024]	Nausea, vomiting, abdominal pain; tremor fingers; jaundice, hepatitis; monocytosis (increased blood monocytes); kidney damage.	Skin, liver, kidneys, CNS, GI tract	[3]	Pungent chloroform-like odor; potential occupational carcinogen.
Tetrachloro-ethylene 127-18-4	237 [35]	1560 [230]	3323 [490]	81 [12]	4.2 [0.61]	Irritation eyes, skin, nose, throat, respiratory system; nausea; flush face, neck; vertigo (an illusion of movement), dizziness, incoordination; headache, somnolence (sleepiness, unnatural drowsiness); skin erythema (skin redness); liver damage.	Eyes, skin, RS, liver, kidneys, CNS	[47]	Mild chloroform-like odor; potential occupational carcinogen.
Tetraethyl lead 78-00-2	0.13 [0.01]	0.75 [0.06]	4.0 [0.30]	0.1[S] [0.013]	0.0024[S] [0.0003]	Insomnia, lassitude, anxiety; tremor, hyper-reflexia, spasticity; bradycardia, hypotension, hypothermia, pallor, nausea, loss of appetite, weight loss; confusion,	CNS, CVS, kidneys, eyes	NA	*Measured as total Pb (no speciation); guideline based on most toxic Pb species.

Chemical CAS No.	1-Hour Air-MEG mg/m^3 [ppm] Health Effect Level			8-Hour Air-MEG mg/m^3 [ppm]	14 Day Air-MEG mg/m^3 [ppm]	Potential Symptoms [N]	Target Organs [N] and Systems	Odor? Threshold mg/m^3 [ppm]	Notes
	Minimal	Significant	Severe						
						hallucinations, psychosis, mania, convulsions, coma; eye irritation.			
Tetramethyl lead 75-74-1	ND	ND	40	0.1[S] [0.013]	0.0024[S] [0.0003]	Insomnia, restlessness, anxiety; hypotension; nausea, loss of appetite; delirium, mania, convulsions; coma.	CNS, CVS, kidneys	NA	*Measured as total Pb (no speciation); guideline based on most toxic Pb species.
Titanium tetrachloride 7550-45-0	5 [0.64]	20 [2.6]	100 [12.9]	0.5 [0.064]	0.012 [0.0015]	Cornea damage, congestion of the mucous membrane of the pharynx, vocal cords, and trachea; stenosis of larynx, trachea and upper bronchi; skin irritation[H].	Skin, eyes, URS[H]	NA	
Toluene 108-88-3	309 [82]	716 [190]	2374 [630]	109 [29]	11 [3]	Irritation eyes, nose; fatigue, weakness, confusion, euphoria, dizziness, headache; dilated pupils, excessive tearing; nervousness, muscle fatigue, insomnia; paresthesia; dermatitis; liver, kidney damage.	Eyes, skin, RS, CNS, liver and kidneys	[2.9]	Pungent, benzene-like odor. CHID under development.
Toluene 2,4-diisocyanate 584-84-9	0.14 [0.02]	0.59 [0.083]	3.6 [0.51]	0.07 [0.01]	0.036 [0.005]	Irritation eyes, skin, nose, throat; choke, paroxysmal cough; chest pain; vomiting, abdominal pain; bronchospasm, pulmonary edema; difficulty breathing, asthma; conjunctivitis, excessive tearing; dermatitis, skin sensitization.	Eyes, skin, RS	NA	Known sensitizer. Subsequent exposures may lower effect concentration. Potential occupational carcinogen; strong, pungent odor.

Chemical CAS No.	1-Hour Air-MEG mg/m^3 [ppm] Health Effect Level Minimal	Significant	Severe	8-Hour Air-MEG mg/m^3 [ppm]	14 Day Air-MEG mg/m^3 [ppm]	Potential Symptoms [?N]	Target Organs [N] and Systems	Odor[?] Threshold mg/m^3 [ppm]	Notes
Trichloroethylene 79-01-6	537 [100]	2687 [500]	26,870 [5000]	270 [50]	6.6 [1.2]	Headache, fatigue, and irritability.	CNS	[28]	
Trichloropropane (1,2,3-) 96-18-4	181 [30]	302 [50]	603 [100]	60[S] [10]	1.5[S] [0.24]	Irritation eyes, nose, throat; CNS depressant/depression; in animals: liver, kidney injury.	Eyes, skin, RS, CNS, liver, kidneys	NA	Dermal exposure may contribute to total dose; potential occupational carcinogen.
Tungsten hexafluoride 7783-82-6	ND	ND	ND	1 [0.125]	0.024 [0.003]	Nausea, vomiting, abdominal pain, convulsions, and kidney damage; irritation of the eyes, nose, throat, and skin.	Kidney, CNS, eyes, skin, URS	NA	These acute symptoms were based on exposure to high levels of fluorides; no known health effects from exposure to tungsten hexafluoride[NJ]; 1-14 day value based on soluble tungsten.
VX 50782-69-9	See Table C-1								
Xylene (mixed) 1330-20-7	650 [150]	868 [200]	3906 [900]	435 [100]	10.6 [2.4]	Lightheadedness, nausea, headache, and ataxia at low doses and confusion; respiratory depression and coma at high doses; above 200 ppm, conjunctivitis, nasal irritation, and sore throat; it is a potent respiratory irritant at high concentrations; dermatitis with prolonged cutaneous	CNS, eyes, skin, RS[H]	[0.081 40]	Sweet, aromatic odor.

Chemical CAS No.	1-Hour Air-MEG mg/m^3 [ppm]			8-Hour Air-MEG mg/m^3 [ppm]	14 Day Air-MEG mg/m^3 [ppm]	Potential Symptoms [N]	Target Organs [N] and Systems	Odor [?] Threshold mg/m^3 [ppm]	Notes
	Health Effect Level								
	Minimal	Significant	Severe						
						exposure.[H]			

FOOTNOTES FOR TABLE C-2 – SHORT-TERM AIR MEGS

c – Ceiling value (ACGIH, 1998).
s – Skin notation; dermal exposures have the potential for significant contribution to overall dose.
† - Compounds classified per ACE Policy for Defensive Measures against Toxic Industrial Chemical Hazards during Military Operations (NATO/PFP, 1996).

CHID – Chemical Hazard Information for Deployments. Additional Fact Sheet information is under development for notated Chemicals.
EKG - electrocardiogram
H – Hazardous Substances Data Base.
I – Acute Exposure Symptoms which may occur at exposures above MEGs-S.
M – National Research Council, Committee on Toxicology. 1997. *Toxicity of Military Smokes and Obscurants*, National Academy Press, Washington, DC
N – National Institute of Safety and Occupational Health (NIOSH) Pocket Guide (unless otherwise noted).
NA – Not Available; data insufficient to derive a value.
ND – Not Determined; data not yet reviewed to derive a value.
NJ – New Jersey Substance Fact Sheet.
NOAEL – No Observable Adverse Effect Level
R – Chemical Hazard Response Information System.
RTECS – Registry of Toxic Effects of Chemical Substances.
T – Compton, James A. F. 1987. *Military Chemical and Biological Agents*, The Telford Press, Caldwell, NJ.

The primary sources of odor thresholds in air were the *Odor Thresholds for Chemicals with Established Occupational Health Standards*, published by the American Industrial Hygiene Association, Akron, OH, 1989, and the N. J. Hazardous Substances Fact Sheets.

TABLE 2-4-1. TARGET ORGANS

TARGET ORGANS	
Eyes	Brain
Skin	Heart
Blood	Pancreas
Bladder	Adrenal Glands
Thyroid	Lungs
Bone	Liver
Fetus	Kidneys
Spleen	

TABLE 2-4-2. TARGET SYSTEMS

TARGET SYSTEMS	
CNS – Central Nervous System	CVS – Cardiovascular System
PNS – Peripheral Nervous System	ChE Inh – Cholinesterase Inhibitor
GI tract – Gastrointestinal Tract	UT – Urogenital Tract
RS – Respiratory System	CRC – Circulatory System
LRS – Lower Respiratory System	IMM – Immune System
URS – Upper Respiratory System	REPR – Reproductive System
ENDO – Endocrine System	HEM – Hemopoietic System
LYMP – Lymphatic System	

TABLE C-3. LONG-TERM, AIR MILITARY EXPOSURE GUIDELINES (1 YEAR DEPLOYMENT)

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Acenaphthene 83-32-9	0.14 [0.023]	NA	Skin and eye irritation, coughing and wheezing.	Skin, eyes, RS, kidney, liver	0.50 [0.08]	
Acenaphthylene 208-96-8	0.028 [0.0045]	D	ND	ND	NA	Little data is available on this compound. Effects may be comparable to other PAHs.
Acetaldehyde 75-07-0	0.0062 [0.0034]	B2	Irritation of the eyes, nose, throat; eye, skin burns; dermatitis; conjunctivitis; cough; CNS depression; delayed pulmonary edema; kidney, reproductive, teratogenic effects; cancer.	RS, eyes, skin, kidneys, CNS, REPR	0.0002-4.14 Green, sweet, fruity odor	Air unit risk based on increased incidence of nasal tumors in rats and laryngeal tumors in hamsters after inhalation exposure.
Acetone 67-64-1	29.0 [12.2]	D	Eye, nose and throat irritation, headache, dizziness, CNS depression, dermatitis.	Eyes, skin, RS, CNS	30.9 [13] Fruity odor	High vapor concentrations produce anesthetic effects.
Acetone cyanohydrin 75-86-5	0.068 [0.020]	NA	Irritation of the eyes, skin, respiratory system; dizziness, weakness, headache, confusion, convulsions; liver, kidney injury; pulmonary edema, asphyxia.	CNS, eyes, skin, RS, CVS, liver, kidneys, GI tract	Cyanide, bitter almond odor	Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Acetonitrile 75-05-8	0.34 [0.20]	D	Irritation of nose, throat; asphyxiation, nausea, vomiting; chest pain; weakness; stupor, convulsions; liver, kidney damage.	Liver, kidneys, RS, CVS, CNS	70 Ether-like odor	
Acrolein 107-02-8	0.000014 [0.0000060]	C	Irritation eyes, skin, mucous membranes; decreased pulmonary function; delayed pulmonary edema; chronic respiratory disease; cancer.	Eyes, skin, RS, heart	0.0525-37 Burnt sweet odor	Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Acrylamide 79-06-1	0.0037 [0.0013]	B2	Irritation of eyes, skin ataxia, numb limbs, abnormal sensations; muscular weakness; absent deep tendon reflex; fatigue, reproductive effects (mammary gland, uterus, testes), cancer, lethality	CNS, PNS, REPR, ENDO, RS, GI tract, eyes, skin	NA	C Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Acrylic acid 79-10-7	0.14 [0.048]	NA	Irritation of eyes, skin, respiratory system; eye, skin burns, skin sensitization; reproductive effects; lung, liver, kidney.	Liver, kidneys, eyes, skin, RS, REPR	0.282-3.12 Rancid, sweet odor	Skin – dermal exposures has the potential or significant contribution to overall dose[Ac].
Acrylonitrile 107-13-1	0.11 [0.049]	B1	Irritation eyes, skin; asphyxia; headache; sneezing; nausea, vomiting; weakness, lightheadedness; skin vesiculation; scaling dermatitis; brain tumors; lung and bowel cancer.	RS, eyes, skin, CVS, liver, kidneys, CNS	8.1-78.75 Onion-garlic pungency	Skin – dermal exposure have the potential for significant contribution to overall dose[Ac]. Air unit risk based on respiratory cancer in humans from occupational inhalation exposure.

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Aldrin 309-00-2	0.00098 [0.000066]	B2	Headache, dizziness; nausea, vomiting, malaise; myoclonic jerks of limbs; clonic, tonic convulsions; coma; hematuria, azotemia, thyroid and adrenal effects, cancer.	CNS, liver, kidneys, skin, LRS, ENDO	0.2536-0.4027	C Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Allyl chloride 107-05-1	0.077 [0.025]	C	Irritation eyes, skin, nose, mucous membranes; pulmonary edema, liver, kidney injury; cancer.	CNS, eyes, skin, RS, liver, kidneys	1.41-75 Green garlic, oniony odor	Dermal exposures may contribute to overall dose.
Ammonia 7664-41-7	0.35 [0.5]	NA	Irritation eyes, nose, throat; dyspnea, bronchospasm; pulmonary edema; pink frothy sputum; skin burns; cancer.	RS, eyes, skin	0.0266-39.6 Pungent, irritating odor	
Aniline 62-52-3	0.19 [0.049]	B2	Headache, weakness, dizziness; cyanosis; dyspnea on effort; tachycardia; irritation of eyes; methemoglobinuria, cirrhosis; tumors of the spleen; cancer.	Blood, CVS, eyes, liver, kidneys, LRS	0.0002-350 Pungent, amine-like odor	Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Antimony trioxide 1309-64-4	0.00014 [0.000020]	NA	Irritation eyes, respiratory system, antimony pneumoconiosis.	RS, liver[I]	NA	
Anthracene 120-12-7	35 [4.2]	D	Skin, nose, throat, and eye irritation, itching, burning, coughing, and wheezing, photosensitizer.	Skin, eyes, RS	Weak aromatic odor	Photosensitizing of this agent can increase dermal effects.

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Arsenic 7440-38-2	0.0011 [0.00036]	A	Ulceration of nasal septum; dermatitis; GI disturbances; peripheral neuropathy; respiratory irritation; hyperpigmentation of skin; lung and lymphatic cancer.	RS, skin, CVS, liver, kidneys	NA	C CHID under development.
Arsine 7784-42-1	0.000034 [0.000011]	NA	Headache, malaise; dyspnea; nausea, vomiting; bronze skin; hemolysis; jaundice; peripheral neuropathy.	Blood, liver, kidneys, lungs, CVS	0.84-2 Garlic-like odor	
Azobenzene 103-33-3	0.15 [0.021]	B2	Azobenzene induced invasive sarcomas in the spleen and other abdominal organs in male and female F344 rats following dietary administration. It is genotoxic and may be converted to benzidine, a known human carcinogen, under the acidic conditions in the stomach[I]; cancer.	GI tract	NA	C
Barium 7440-39-3	0.0034 [0.00061]	NA	Irritation to eyes, upper respiratory system, acute lung and gastrointestinal effects; baritosis.	Eyes, skin , RS, GI tract, fetus	NA	

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Benzene 71-43-2	0.039 [0.012]	A	Irritation of eyes, skin, nose, respiratory system; giddiness; headache, nausea, staggered gait; fatigue, anorexia, lassitude (weakness, exhaustion); dermatitis; bone marrow depression, leukemia; cancer.	HEM, eyes, skin, RS, blood, CNS	4.5-270 Sweet, solvent odor	Skin – dermal exposures have the potential for significant contribution to overall dose[Ac]. Air unit risk based on leukemia in humans exposed by inhalation. Chronic exposures to low concentrations causes bone marrow depression. CHID under development.
Benzidine 92-87-5	0.000072 [0.0000095]	A	Hematuria; secondary anemia from hemolysis; acute cystitis; acute liver disorders; dermatitis; painful irregular urination; cancer.	Bladder, skin, kidneys, liver, blood	NA	C Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Benzo(a)anthracene 56-55-3	0.054 [0.0058]	B2	Benzo(a)anthracene produced tumors in mice exposed by gavage; intraperitoneal, subcutaneous or intramuscular injection; and topical application[I]; cancer.	RS, liver, GI tract [I]	NA	C

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Benzo(a)pyrene 50-32-8	0.0054 [0.00053]	B2	Repeated Benzo(a)pyrene administration has been associated with increased incidences of total tumors and of tumors at the site of exposure in dietary, gavage, inhalation, intratracheal instillation, dermal and subcutaneous studies in numerous strains of at least four species of rodents and several primates[I]; cancer.	GI tract, RS, skin[I]	Faint aromatic odor	
Benzo(b)fluoranthene 205-99-2	0.054 [0.0053]	B2	Benzo(b)fluoranthene produced tumors in mice after lung implantation, intraperitoneal or subcutaneous injection, and skin painting[I]; cancer.	RS, liver, skin[I]	NA	C
Benzo(k)fluoranthene 207-08-0	0.54 [0.053]	B2	Benzo(k)fluoranthene produced tumors after lung implantation in mice and when administered with a promoting agent in skin-painting studies[I]; cancer.	RS, skin, liver[I]	NA	C
Beryllium 7440-41-7	0.000014 [0.000037]	B1	Sensitization, irritation of eyes; dermatitis; cumulative lung damage berylliosis - chronic exposure: anorexia, low weight, weakness, chest pain, cough, clubbing of fingers, cyanosis, pulmonary insufficiency; lung cancer [I,N].	Eyes, skin, RS, CNS[I,N]	NA	Air unit risk based on lung cancer in humans from occupational inhalation exposures.

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Bis (2-ethylhexyl) phthalate 117-81-7	0.12 [.00767]	B2	Eye irritation, liver damage, possible teratogenic and carcinogenic effects.	Eyes, skin, RS., CNS, liver, REPR, GI tract	Odorless	C Slope factor based on dose-response increase of liver tumors in rats.
Bis-2-Chloro-1-methylethyl ether 108-60-1	0.0014 [0.0002]	C	Cancer	Liver[H]	NA	C
Bis-2-Chloroethyl ether 111-44-4	0.015 [0.0025]	B2	Cancer	Liver[H]	[0.049] Pungent, sweet, chloroform-like odor	C
Boron 7440-42-8	0.014 [0.031]	NA	Respiratory irritation, bronchitis[H].	RS[H]	NA	
Boron trifluoride 7637-07-2	0.0048 [0.0017]	NA	Irritation eyes, skin, nose, respiratory system; epistaxis (nosebleed); pneumo nia; kidney damage.	Eyes, skin, RS, kidneys	4.5 Pungent, irritating	
Bromoethylene 593-60-2	0.0021 [0.00047]	B2	Irritation eyes, skin; dizziness, confusion, incoordination, narcosis, nausea, vomiting[N]; liver injury and cancer[H].	Eyes, skin, CNS, liver, GI tract[N]	Characteristic pungent odor	Bromoethene appeared carcinogenic (in liver) in this study at higher doses.

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Bromoform 75-25-2	0.13 [0.012]	B2	Irritation of eyes, skin, respiratory system, CNS depression, liver, kidney damage, cancer of the GI tract.	GI tract, eyes, skin, RS, liver, kidneys	5300 Odor similar to chloroform	C Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Butadiene (1,3-) 106-99-0	0.017 [0.0077]	B2	Irritation of the eyes, nose and throat; drowsiness, light-headedness; teratogenic, reproductive effects; cancer.	Eyes, RS, REPR, heart, HEM, CVS	0.352-2.86	C
sec-Butylbenzene 135-98-8	0.025 [0.00462]	NA	Irritation of eyes, nose, throat, and skin, CNS depression, incoordination, nausea, general anesthetic effects.	Eyes, RS, skin	NA	
Cadmium (elemental) 7440-43-9	0.00024 [0.000053]	B1	Pulmonary edema, dyspnea, cough, tight chest, substernal pain, headache, chills, muscular aches, nausea, vomiting, diarrhea, emphysema, proteinuria, anosmia (loss of sense of smell), mild anemia, cancer.	RS, kidneys, REPR, blood, GI tract	NA	C
Cadmium (compounds)	0.000049	NA	Cancer; kidney effects; metal fume fever tumors of lung, trachea, bronchus (cancer deaths) in human occupational epidemiology study.	RS, kidneys	NA	

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Carbon disulfide 75-15-0	0.48 [0.15]	NA	Dizziness, headache, nervousness, anorexia, polyneuropathy, psychosis, Parkinson-like syndrome, ocular changes, coronary heart disease, gastritis, kidney, liver injury, dermatitis, reproductive effects.	PNS, CNS, CVS, eyes, kidneys, liver, skin, REPR	0.0243-23.1 Disagreeable sweet odor	Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Carbon monoxide 630-08-0	3.3 [3]		Headache, tachypnea, nausea, weakness, dizziness, confusion, hallucinations, cyanosis, electrocardiogram alterations, angina, syncope	CNS, CVS, fetus	NA	See Section 4.4.1 for additional information.
Carbon tetrachloride 56-23-5	0.32 [0.051]	B2	Irritation eyes, skin; CNS depression; nausea, vomiting; liver, kidney injury; drowsiness, dizziness, incoordination, cancer.	Eyes, skin, liver, CNS, RS, kidneys	300-1500 Sweet, pungent odor	C Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Chlordane 57-75-9	0.00048 [0.000029]	B2	Blurred vision; confusion, ataxia, delirium; cough; abdominal pain, nausea, vomiting, diarrhea; irritability, tremor, convulsions; anuria; lung, liver and kidney damage; cancer.	Liver, ENDO, IMM, CNS, eyes, kidneys	0.0084-0.0419	Skin – dermal exposures have the potential for significant contribution to overall dose[AC]. Compound is lipid soluble and expected to bioaccumulate. Air unit risk calculated based on hepatocellular carcinoma in mouse drinking water study.

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Chlorine dioxide 10049-04-4	0.0068 [0.0025]	NA	Irritation of eyes, nose, throat; cough, wheezing, bronchitis, pulmonary edema; chronic bronchitis.	RS, eyes	0.3 Sharp, pungent odor	
Chloroacetophenone (2-) (CN) 532-27-4	0.00021 [0.000032]	NA	Lacrimation, irritation of the skin, rashes in tender skin areas of the armpits, knees, elbows, areas of the crotch and buttocks[T].	RS, skin, eyes[T]	0.102-0.15 Sharp and irritating odor	
Chlorobenzilate 510-15-6	0.0612 [0.0046]	B2	Cancer	Liver[H]	NA	C Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Chloro-1,3-butadiene (2-) 126-99-8	0.048 [0.013]	NA	Upper respiratory system effects.	URS, CNS, blood, liver[Ac]	NA	Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Chloro-1,1-difluoroethane (1-) 75-68-3	34.2 [8.3]	NA	None identified up to a human equivalent concentration of 14,710 mg/m3[I]	CNS, CVS, LRS, fetus	NA	Effects at very high doses: A LOAEL was not achieved.
Chlorodifluoromethane 75-45-6	3.42 [9.7]	NA	Irritation respiratory system; confusion, drowsiness, ringing in ears; heart palpitations, cardiac arrhythmias; asphyxiation; liver, kidney, spleen injury.	Kidneys, ENDO, RS, CVS, CNS, liver	NA	

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Chloroethane 75-00-3	6.8 [2.6]	NA	Effects on fetus.	Fetus, CNS, CVS	[4.2] Pungent, ether-like odor	
Chloroform 67-66-3	0.21 [0.043]	B2	Irritation eyes, skin; dizziness, mental dullness, nausea, confusion, headache, fatigue; anesthesia; enlarged liver; cancer.	Kidneys, liver, heart, eyes, skin, CNS	250-1000 Pleasant, ether-like odor	C
Chloromethane 74-87-3	2.7 [1.3]	C	Tumors[H]; cancer.	Kidneys[H]	[10] Faint, sweet odor	
Chloropropane (2-) 75-29-6	0.68 [0.21]	NA	Liver effects	Liver[H]	NA	
Chromium Metal and Cr III compounds 7440-47/16065-83-1	0.012	NA	Irritation; dermatitis.	Eyes, skin, RS	NA	
Chromium (VI) (water soluble) CrVI 18540-29-9	0.00068	NA	Nasal irritation and atrophy; decreased pulmonary function; liver, kidney effects; cancer.	RS; liver; kidneys	NA	

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Chromium (VI) (insoluble) CrVI 18540-29-9	0.000068	A	Irritation to eyes; dermal sensitization; lung, liver, kidney effects, cancer[N,I].	Skin, eyes, LRS, liver, kidneys, blood, IMM[N,I]	NA	Air unit risk based on lung cancer in humans from occupational inhalation exposure. Trivalent chromium compounds have not been reported as carcinogenic by any route of administration[I].
Chrysene 218-01-9	5.5 [0.58]	B2	Chrysene produced carcinomas and malignant lymphomas in mice after intraperitoneal injection and skin carcinomas in mice following dermal exposure[I]; cancer.	Liver, LRS, skin [I]	NA	C Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Cumene 98-82-8	2.74 [0.6]	D	Irritation to eyes, skin, mucous membranes; dermatitis; headache, narcosis, coma.	CNS, URS, eyes, skin	0.04-6.4 Sharp, aromatic odor	
Cyclopentadiene 542-92-7	2.1 [0.76]	NA	Irritation of eyes, nose; liver, kidney effects.	Liver, kidneys, eyes, URS	5.07 Turpentine-like odor	

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
P,p'-DDT 50-29-3	0.049 [0.0034]	B2	Irritation eyes, skin; paresthesia tongue, lips, face; tremor; apprehension, dizziness, confusion, malaise, headache, fatigue; convulsions; paresis hands; vomiting, cancer.	Liver, eyes, skin, CNS, PNS, kidneys, LRS, LYM	5.07 Slight aromatic odor	
Dibenzo(a,h)anthracene 53-70-3	0.0054 [0.00048]	B2	Bibenzo(a,h)anthracene produced carcinomas in mice following oral or dermal exposure and injection site tumors in several species following subcutaneous or intramuscular; cancer.	Skin, RS, REPR [I]	NA	C
Dibromo -3-chloropropane (1,2-) 96-12-8	0.00014 [0.000014]	B2	Irritation eyes, skin, nose, throat; drowsiness; nausea; vomiting; pulmonary edema; liver, kidney effects, cancer.	RS, eyes, skin, liver, kidneys, blood, REPR	0.1-0.29 Pungent odor	Slope factor based on tumors of the nasal cavity in rat and mouse inhalation studies.
Dichlorobenzene (1,2-) 95-50-1	1.4 [0.23]	D	Irritation eyes, nose; liver, kidney damage, skin blisters.	Eyes, skin, URS, liver, kidneys	12-300 Pleasant, aromatic odor	
Dichlorobenzene (1,4-) 106-46-7	1.7 [0.28]	B2	Eye irritation, periorbital swelling; profuse rhinitis; headaches, anorexia, nausea, vomiting; low weight, jaundice, cirrhosis; liver and kidney cancer.	Liver, URS, eyes, kidneys	90-180 Mothball odor	

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Dichloro-2-butene (1,4-) 764-41-0	0.0018 [0.00036]	B2	Cancer	URS[H]	Sweet, pungent odor	C Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Dichlorodifluoromethane 75-71-8	99.0 [24.4]	NA	Dizziness, tremor, asphyxiation, unconsciousness, cardiac arrhythmias, cardiac arrest, liver effects.	Liver, CVS, PNS	NA	
Dichloroethane (1,1-) 75-34-3	3.42 0.85	C	Irritation skin; CNS depression, liver, kidney, lung damage; cancer.	Kidneys, skin, liver, LRS, CNS	445.5-810 Chloroform-like odor	
Dichloroethane (1,2-) 107-06-2	0.18 [0.045]	B2	Liver effects, narcosis[Ac]; cancer.	Liver, CNS	24-440 Sweet odor	C
Dichloroethylene (1,1-) 75-35-4	0.096 [0.024]	C	Cancer	Kidneys, liver, CNS	2000-4000 Sweet, chloroformish odor	C
Dichloropropane (1,2-) 78-87-5	0.022 [0.0048]	NA	Nasal mucosa hyperplasia, CNS, liver, kidney effects.	URS, CNS, liver, kidneys[Ac]	1.1667-606.666 Sweet odor	

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Dichloropropene (1,3-) 542-75-6	0.014 [0.0030]	B2	Irritation eyes, skin, respiratory system; eyes, skin burns; lacrimation; headache, dizziness; liver, kidney damage; cancer.	URS, CNS, liver, kidneys[Ac]	Sharp, sweet, chloroform-like odor	Skin – dermal exposures have the potential for significant contribution to overall dose[Ac]. Slope factor based on findings of lung adenoma in 2-year mouse inhalation study.
Dichlorvos 62-73-7	0.0018 [0.0002]	B2	Irritation eyes, skin; miosis, aching eyes, rhinitis; headaches; chest tight, wheezing, laryngeal spasms, salavation; cyanosis; anorexia, nausea, vomiting, diarrhea sweating; muscle fasciculations, paralysis, giddiness, ataxia, convulsions, low blood pressure, cardiac irregularities; cancer.	Eyes, skin, ChE Inh, CNS, RS, CVS	Mild, aromatic odor	Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Dicyclopentadiene 77-73-6	0.014 [0.0025]	NA	Irritation eyes, skin, nose, throat; incoordination, headaches; sneezing, cough; skin blisters; kidney, lung damage.	Eyes, skin, kidneys, RS, CNS, eyes, skin	0.03-0.054 Sharp, sweet odor	
Dieldrin 60-57-1	0.0010 0.000067	B2	Headache, dizziness; nausea, vomiting, malaise, sweating; myoclonic limb jerks; clonic, tonic convulsions; coma; liver, kidney damage, cancer.	Liver, CNS, kidneys, skin, RS, ENDO	[0.04] Mild, chemical odor	C Skin – dermal exposures have the potential for significant contribution to overall dose.[Ac].

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Diesel engine emissions	0.0034	NA	Eye irritation; pulmonary function changes; lung inflammation; lung tumors.	Eyes, URS	NA	Measured by diesel particulate matter.
Difluoroethane (1,1-) 75-37-6	27.4 [10.0]	NA	Nasal olfactory epithelium atrophy at high doses; CNS depression at extremely high doses.	URS; CNS	NA	A LOAEL was not determined.
Dimethylformamide (N,N-) 68-12-2	0.062 [0.021]	NA	Irritation eyes, skin, respiratory system; nausea, vomiting, colic; liver damage, enlarged liver; high blood pressure; face flushing; dermatitis; kidney, heart damage.	Liver, GI tract, RS, eyes, skin, kidneys, CVS	300 Faint amine-like odor	Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Diphenylhydrazine (1,2-) 122-66-7	0.022 [0.0029]	B2	Cancer	Liver[I]	NA	C
Epichlorohydrin 106-89-8	0.0068 [0.0018]	B2	Irritation eyes, skin with deep pain; nausea, vomiting; abdominal pain; respiratory distress, cough; cyanosis reproductive effects; cancer.	RS, eyes, skin, kidneys, liver, REPR	50-80 Chloroform-like odor	Skin – dermal exposures have the potential for significant contribution to overall dose[Ac]. Slope factor based on tumors of the nasal cavity in rat inhalation study.

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Epoxybutane (1,2-) 106-88-7	0.014 [0.0046]	NA	Irritation nose, respiratory system; effects on blood.	Respiratory system, blood[I]	Disagreeable odor	
Ethoxyethanol (2-) 110-80-5	1.4 [0.37]	NA	Irritation eyes, respiratory system; blood changes; liver, kidney, lung damage; reproductive, teratogenic effects.	Blood, eyes, kidneys, liver, HEM, REPR, RS	[2.7] Mild, agreeable, ether-like odor	Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Ethyl benzene 100-41-4	2.95 [0.68]	D	Irritation eyes, skin, mucous membrane; headache; dermatitis; narcosis, coma.	Fetus, liver, kidneys, blood, eyes, skin, RS, CNS	8.7-870 Aromatic odor	
Ethyl chloride 75-00-3	6.8 [2.6]	NA	Incoordination, inebriation; abdominal cramps; cardiac arrhythmias, cardiac arrest; liver, kidney damage.	Fetus, liver, kidneys, RS, CNS	[4.2] Pungent, ether-like	Skin – dermal exposure have the potential for significant contribution to overall dose[Ac].
Ethylene dibromide 106-93-4	0.0014 [0.00018]	B2	Reproductive effects, cancer.	REPR	[8.1-10] Sweet odor	Slope factor was based on tumors of the nasal cavity in 88 to 103-week rat inhalation study.
Ethylene glycol monobutyl ether 111-76-2	0.14 [0.028]	NA	Altered hematology.	Blood[H]	[0.1] Mild, ether-like odor	

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Ethylene oxide 75-21-8	0.048 [0.027]	B1	Irritation eyes, skin, nose, throat; peculiar taste; headache, nausea; vomiting, diarrhea; dyspnea, cyanosis, pulmonary edema; incoordination; EKG abnormalities; convulsions, liver, kidney damage in animals; cancer.	Eyes, skin, RS, liver, CNS, blood, kidneys, REPR	520-1400 Sweet olefininic odor	C
Fluoranthene 206-44-0	1.4 [0.17]	D	ND	ND	NA	Little toxicity data is available for this compound.
Fluorene 86-73-7	1.4 [0.17]	D	Irritation of skin and eyes.	Skin, eyes.	NA	Little toxicity data is available for this compound.
Formaldehyde 50-00-0	0.25 [0.20]	B1	Irritation eyes, nose, throat, respiratory system; lacrimation; cough, bronchospasm; cancer.	RS, eyes	1.47-73.5 Pungent, hay odor	C Minor irritation of the nose and throat and skin sensitization may occur at this level.
Furfural 98-01-1	0.34 [0.087]	NA	Irritation eyes, skin, upper respiratory tract; headache; dermatitis.	RS, eyes, skin	0.024-20 Almond odor	Skin – dermal exposures have the potential for significant contribution to overall dose[AC].

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Glycidaldehyde 765-34-4	0.0068 [0.0023]	B2	Body weight changes, kidney effects.	Kidneys[H]	Pungent, aldehyde-like odor	
Heptachlor 76-44-8	0.0037 [0.00024]	B2	Tremor, convulsions; liver damage, cancer.	Liver, CNS	0.306 Camphor-like odor	C Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Heptachlor epoxide 1024-57-3	0.0018 [0.00012]	B2	Cancer	Liver[I]	NA	C
Hexachlorobenzene 118-74-1	0.000049 [0.0000052]	B2	Liver effects; metabolic disorders (e.g. thyroid disorders), cancer[Ac,I]	Liver, ENDO, kidneys[I]	NA	C Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Hexachlorobutadiene 87-68-3	0.0052 0.00049	C	Irritation, eyes, skin, respiratory system; kidney damage; liver cancer in animals.	Eyes, skin, RS, kidneys	12 Turpentine-like odor	Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Alpha-Hexachlorocyclohexane (HCH) 319-84-6	0.0027 [0.00022]	B2	Cancer	Liver[I]	NA	C

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Beta Hexachlorocyclohexane (HCH) 319-85-7	0.0090 [0.00076]	C	Cancer	Liver[J]	NA	C
Technical Hexachlorocyclohexane (HCH) 608-73-1	0.00094 [0.00079]	B2	Cancer	Liver[J]	NA	C
Hexachlorocyclopentadiene 77-47-4	0.076 [0.0068]	D	Irritating to eyes, skin, respiratory system; lacrimation; sneezing, cough, dyspnea, salivation, pulmonary edema; nausea, vomiting, diarrhea; liver, kidney injury in animals.	RS, eyes, skin, liver, kidneys	1.5-3.3 Pungent, unpleasant odor	Effects are concentration rather than time dependent.
Hexachlorodibenzodioxin mix 19408-74-3	0.0000037	B2	Cancer	Liver[J]	NA	C

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Hexachloroethane 67-72-1	1.20 [0.12]	C	Irritating to eyes, skin, mucous membranes; kidney; liver; CNS, cancer.	Eyes, skin, RS, liver, kidneys, CNS	[0.15] Camphor-like odor	C Skin – dermal exposures have the potential for significant contribution to overall dose[AC]. The MEG for hexachloroethane does not refer to HC Smoke. The toxicity of HC Smoke is based on the production of $ZnCl_2$ and respiratory effects and alvelogenic carcinoma. The PEGL for $ZnCl_2$ is 0.2 mg/m^3.
Hexamethylene diisocyanate (1,6-) 822-06-0	0.00014 [0.00002]	NA	Irritation eyes, skin, mucous membranes, respiratory system; cough, dyspnea, bronchitis, wheezing, pulmonary edema, asthma.	RS, eyes, skin	Sharp, pungent odor	
Hexane (other isomers)	43 [12.2]	NA	Irritation eyes, nose, throat; CNS effects (peripheral neuropathy for hexane)	CNS; eyes, URS	NA	
Hexane (n-) 110-54-3	4.3 [1.2]	NA	Irritation eyes, nose; light-headedness; nausea, headache; peripheral neuropathy: numbness extremities, muscle weakness; dermatitis; giddiness.	CNS, eyes, skin, URS, PNS	[130] Gasoline-like odor	Skin – dermal exposure have the potential for significant contribution to overall dose[Ac].

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Hydrazine 302-01-2	0.00098 [0.00075]	B2	Irritation eyes, skin, nose, throat; temporary blindness; dizziness, nausea; dermatitis; eyes, skin burns; bronchitis, pulmonary edema; liver, kidney damage, convulsions; cancer.	RS, eyes, skin, CNS, liver, kidneys	3-4 Ammonical, fishy odor	C Skin – dermal exposures have the potential for significant contribution to overall dose[AC].
Hydrogen chloride 7647-01-0	0.014 [0.0092]	NA	Irritation nose, throat, larynx; cough, choking; dermatitis; larygeal spasm; pulmonary edema.	RS, eyes, skin	[0.77] Pungent, irritating odor	Asthmatics may experience adverse effects above 3 ppm (4.47 mg/m^3).
Hydrogen cyanide 74-90-8	0.0021 [0.0019]	NA	Asphyxia, weakness, headache, confusion; nausea, vomiting; increased rate and depth of respiration or respiration slow and gasping; thyroid, blood changes.	CNS, CVS, ENDO, blood	0.9-5 Bitter, almond, slightly sharp odor	Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Hydrogen sulfide 7783-06-4	0.15 [0.11]	NA	Irritation eyes, respiratory system; apnea; conjunctivitis, eye pain, lacrimation photophobia (abnormal visual intolerance to light), corneal vesiculation; dizziness, headache, fatigue, insomnia, convulsions, coma; GI disturbances.	URS, eyes, CNS	0.0007-0.014	Rotten egg odor below 0.03 mg/m^3; higher, toxic concentrations rapidly deaden sense of smell.
Indeno(1,2,3-c,d)pyrene 193-39-5	0.054 [0.0048]	B2	Indeno(1,2,3-c,d)pyrene produced tumors in mice following lung implants, subcutaneous injection and dermal exposure; cancer.	RS, skin [I]	NA	C; skin exposure site cancers

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Lead 7439-92-1	0.0015	NA	Weakness, lassitude, insomnia, facial pallor; anorexia, constipation, abdominal pain; anemia; tremor, paralysis wrist/ankles; kidney disease; irritation eyes; hypo/hyper tension.	CNS, PNS, blood, CVS, kidneys, REPR, fetus, GI tract, eyes	NA	See section 4.4.1 for more information. CHID under development.
Manganese 7439-96-5	0.00034 [0.00015]	D	Dry throat, cough, chest, tightness, dyspnea, rales, flu-like fever, low-back pain; vomiting; malaise; fatigue; kidney damage; Parkinson's asthenia (weakness), insomnia, mental confusions; metal fumes fever.	CNS, RS, blood, kidneys	NA	Neurobehavioral effects are a concern at moderate levels.
Mercury (inorganic) 7439-97-6	0.00021 [0.000025]	D	Irritating to eyes, skin; cough, chest pain, dyspnea, bronchitis, pneumonitis; tremor, insomnia, irritability, indecision, headache, fatigue, weakness; stomatitis, salivation, GI distress, anorexia, low-weight, proteinuria.	Eyes, skin, CNS, RS, kidneys	NA	Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Methoxyethanol (2-) 109-86-4	0.14 [0.044]	NA	Reproductive effects (testes).	REPR, CNS, blood	[2.3] Mild, ether-like	Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Methylacrylonitrile 126-98-7	0.067 [0.025]	NA	Irritation eyes, skin; lacrimation; CNS effects, convulsions, loss of motor control; liver.	Liver, CNS, eyes, skin	6-42 Bitter almond odor	
Methyl Bromide 74-83-9	0.09 [0.024]	NA	Lesions of the nasal cavity.	URS, heart, GI tract, CNS, blood[I]	NA	Neurological effects may not be reversible.
Methylcyclohexane 108-87-2	39.3 [9.79]	NA	Irritating to eyes, skin, nose, throat; light-headedness, drowsiness, narcosis, kidneys.	Kidneys, eyes, skin, URS, CNS	2000 Faint, benzene-like odor	
Methylenebis-2-chloroaniline (4,4-) 101-14-4	0.0027 [0.00024]	B2	Hematuria, cyanosis, nausea, methemoglobinemia, kidney irritation, cancer.	LRS, liver, blood, kidneys	NA	C Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Methylene chloride 75-09-2	2.1 [0.59]	B2	Irritating to eyes, skin; fatigue, weakness, somnolence, light-headedness; numb tingling limbs; nausea, cancer.	Liver, eyes, skin, CNS, CVS, LRS, REPR, GI tract	540-2160 Sweet odor	Slope factor based on combined adenomas and carcinomas in 2-year mouse inhalation studies.
Methylenediphenyl isocyanate (4,4-) 101-68-8	0.0013 [0.00012]	NA	Irritating to eyes, nose, throat; respiratory sensitization, cough, pulmonary secretions, chest pain, dyspnea, asthma.	RS, eyes	NA	

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Methyl ethyl ketone 78-93-3	14.4 [4.88]	D	Irritation, CNS, reproductive effects [AC].	Fetus, CNS	0.7375-147.5 Sweet, acetone-like odor	Dermal exposure may contribute to overall dose.
Methyl is obutyl ketone 108-10-1	0.55 [0.13]	NA	Irritation, narcosis, liver, kidneys[AC].	Liver, kidneys, CNS	0.41-192.7 Sweet, sharp odor	
Methyl styrene (mixture) 2501-31-54	0.027 [0.0057]	NA	Irritation nasal cavity, respiratory system.	RS	Strong disagreeable odor	
Methyl tert-butyl ether 1634-04-4	2.1 [0.57]	NA	Liver, kidney, effects, prostration[I].	Liver, kidneys, eyes	Terpene-like odor	
Naphthalene 91-20-3	0.0071 [0.0014]	C	Irritation eyes, nose, throat; respiratory sensitization, cough, pulmonary secretions, chest pain, dyspnea; asthma; hyperplasia and metaplasia of respiratory and olfactory epithelium, hematotoxicity, renal failure; cancer	RS, eyes, blood, kidneys	1.5-125 Mothball, tar-like	Skin – dermal exposures have the potential for significant contribution to overall dose[Ac]. Hemolytic anemia may occur at lower doses in those with (genetic) G-6-PD deficiencies. See RD 4.9.2

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Nickel (elemental/metal) 7440-02-0	0.037 [0.015]	NA	Dermatitis, pneumoconiosis, kidney effects.	Skin , LRS, kidney	NA	
Nickel (soluble compounds)	0.00014	NA	Irritation; dermatitis, chronic active inflammation and lung fibrosis, CNS effects.	CNS, LRS, skin	NA	
Nickel (insoluble compounds)	0.0049	NA	Irritation; dermatitis, cancer (lung).	LRS, skin	NA	
Nickel carbonyl 13463-39-3	0.00085 [0.0012]	NA	Irritation; CNS; respiratory effects; cancer.	LRS, CNS, skin	NA	
Nickel subsulfide 12035-72-2	0.001 [0.001]	NA	Cancer (lung); irritation; dermatitis.	LRS, skin	NA	
Nickel refinery dust	0.020	A	Sensitization dermatitis, allergic asthma, pneumonitis, cancer.	LRS, skin	NA	C

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Nitroaniline (2-) 88-74-4	0.0014 [0.00024]	NA	Hematological effects.	Blood[H]	Musty odor	
Nitrobenzene 98-95-3	0.014 [0.0027]	D	Irritation eyes, skin, anoxia; dermatitis; anemia; methemoglobinemia; liver, kidney damage, testicular effects.	Eyes, skin, blood, ENDO, kidneys, liver, CVS REPR	0.0235-9.5 Shoe polish, pungent odor	Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Nitrogen dioxide	0.1 [0.053]	NA	Irritation eyes, nose, throat; cough, mucoid frothy sputum, decreased pulmonary function, chronic bronchitis, dyspnea; chest pain, pulmonary edema, cyanosis, tachypnea, tachycardia	RS, eyes, CVS	NA	See Section 4.4.1 for more information. CHID under development.
Nitropropane (2-) 79-46-9	0.0018 [0.00049]	B2	Irritation eyes, skin, nose, respiratory system; headache, anorexia, nausea, vomiting, diarrhea; kidney, liver damage, cancer.	Eyes, skin, liver, RS, CNS	17.5-1029 Pleasant, fruity odor	C RfC based on LOAEL of 78 mg/m^3 for liver lesions in 22-month rat inhalation study.
Nitroso-di-n-butylamine (N-) 924-16-3	0.003	B2	Cancer.	Bladder, GI tract, LRS, liver[I]	NA	C

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Nitrosodiethylamine (N-) 55-18-5	0.00011 [0.000027]	B2	Acts transplacentally, trends for tumors of the nasopharynx, lower jaw, stomach, kidney, ovaries, seminal vesicles, and esophagus. Dose-related increases in incidence of upper GI tumors and liver cell tumors were observed in mice, and tracheal and liver cell tumors were observed in hamsters[I]; cancer.	Liver, GI tract, RS[I]	NA	C
Nitrosodimethylamine (N-) 62-75-9	0.00034 [0.00011]	B2	Nausea, vomiting, diarrhea, abdominal cramps; headache; fever; enlarged liver, jaundice; decreased liver, kidney, pulmonary function, cancer.	LRS, liver, kidneys[I], GI tract	NA	C Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].
Nitrosopyrrolidine (N-) 930-55-2	0.0079 [0.0019]	B2	Liver cancer, lung adenomas, papillary mesotheliomas of the testes[I].	Liver, LRS, REPR[I]	NA	
Ozone 10028-15-6	0.052 [0.027]	NA	Irritation eyes, mucus membranes: pulmonary edema; chronic respiratory disease; headache	Eyes, RS	NA	See Section 4.4.1 for additional information. MEG is based on a moderate work level. CHID under development.
Particulate [<2.5? (PM-2.5)]	0.04	NA	Irritation eyes, skin, throat, respiratory system, pulmonary alveolar proteinosis, pulmonary fibrosis	Eyes, skin, LRS	NA	See Section 4.4.1 for additional information.

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Particulate [<10? (PM_{10})]	0.07	NA	Irritation eyes, skin, throat, respiratory system,	Eyes, skin, URS	NA	See section 4.4.1 for additional information.
Phenanthrene 85-01-8	0.042 [0.0058]	D	Skin, eyes, nose, and throat irritation, blistering, respiratory effects, skin photosensitization.	Skin, eyes, RS	Faint aromatic odor	Little toxicity data available for this compound. Photosensitizarion of chemical may increase dermal effects.
Phosphine 7803-51-2	0.0021 [0.0015]	D	Nausea, vomiting, abdominal pain, diarrhea; thirst; chest tightness, dyspnea muscle pain, chills; stupor or syncope; pulmonary edema.	CNS, LRS, GI tract	0.028-3.6 Disagreeable odor of rotten fish or garlic	
Phosphoric acid 7664-38-2	0.024 [0.0061]	NA	Irritation eyes, skin, respiratory system; dermatitis; eye, skin burns.	LRS, eyes, skin	NA	
Phthalic anhydride 85-44-9	0.082 [0.014]	NA	Irritation eyes, skin, upper respiratory system; conjunctivitis; nasal ulcer bleeding; bronchitis, bronchial asthma; dermatitis; liver, kidney damage.	RS, eyes, skin, liver, kidneys	[0.05] Acrid odor	
Polychlorinated biphenyls 1336-36-3	0.0084	B2	Cancer	Liver, GI tract, blood, skin, ENDO[I]	Mild aromatic odor	C

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
n-Propylbenzene 103-65-1	0.025 [.0052]	D	Irritation of eyes, nose, throat, and skin, CNS depression, incoordination, nausea, general anesthetic effects.	Eyes, RS, skin	NA	Acute exposures produce general anesthetic effects.
Propylene glycol monomethyl ether 107-98-2	14 [3.7]		Irritation eyes, skin, nose, throat; headache, nausea, light-headedness, drowsiness, incoordination; vomiting, diarrhea.	CNS, eyes. skin, URS	[10] Sweet, ether-like odor	
Propylene oxide 75-56-9	0.29 [0.12]	B2	Irritation eyes, skin, respiratory system; CNS depression, liver damage, blisters, burns, cancer[Ns, Ac, N].	Eyes, skin, URS, CNS, liver	24.75-500 Sweet, alcoholic odor	Slope factor based on tumors of the nasal cavity in 2-year mouse inhalation study.
Pyrene 129-00-0	0.105 [0.013]	D	Skin irritation.	Skin	NA	Limited toxicity data available for this compound.
Strontium 7440-24-6	1.51 [0.42]	NA	Skin and eye irritation, altered heart function, bone abnormalities.	Bone, heart, skin, eyes	NA	Based on USEPA extrapolation from oral exposure data.

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Styrene 100-42-5	2.0 [0.48]	NA	Irritation, eyes, nose, respiratory system; headache, fatigue, dizziness, confusion, malaise, drowsiness, weakness, unsteady gait, narcosis; defatting dermatitis; liver injury, reproductive effects.	CNS, eyes, skin, RS, liver, REPR	0.2021-860 Solvent-like rubbery odor	
Sulfur dioxide	0.13 [0.05]	NA	Irritation eyes, mucus membranes: pulmonary edema; chronic respiratory disease; headache	Eyes, RS	NA	See Section 4.4.1 for additional information. CHID under development.
Tetrachlorodibenzodioxin (TCDD) (2,3,7,8-) 1746-01-6	0.00000011	B2	Irritation eyes; allergic dermatitis, chloracne; porphyria; GI disturbances; possible reproductive, teratogenic effects; liver, kidney damage; hemorrhage; cancer.	Eyes, skin, liver, kidneys, RS, REPR	NA	C
Tetrachloroethane (1,1,1,2-) 630-20-6	0.65 [0.094]	C	Irritation eyes, skin; weakness, restlessness, irregular respiration, muscle incoordination, liver changes; cancer.	Liver, skin, kidneys, CNS, GI tract	NA	C
Tetrachloroethane (1,1,2,2-) 79-34-5	0.083 [0.012]	C	Nausea, vomiting, abdominal pain; tremor fingers; jaundice, hepatitis; liver tenderness, dermatitis, monocytosis (increased blood monocytes); kidney damage; cancer.	Liver, skin, kidneys, CNS, GI tract	21-35 Sickly sweet odor	C Skin – dermal exposures have the potential for significant contribution to overall dose[Ac].

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Tetrafluoroethane (1,1,1,2-) 811-97-2	55.0 [13.0]	NA	Reproductive effects (testes).	REPR	NA	
Toluene 108-88-3	4.6 [1.2]	D	Irritation eyes, nose; fatigue, weakness, confusion, euphoria, dizziness, headache; dilated pupils, lacrimation (discharge of tears); nervousness, muscle fatigue, insomnia; paresthesia; dermatitis; liver, kidney damage.	CNS, URS, eyes, skin, liver and kidneys	[2.9] Pungent, benzene-like odor	Skin – dermal exposures have the potential for significant contribution to overall dose[Ac]. CHID under development.
Toxaphene 8001-35-2	0.015 [0.00088]	B2	Nausea, confusion, agitation, tremor, convulsions, unconsciousness; dry, red skin, cancer.	Liver, CNS, skin	2.366 Mild piney, chlorine, camphor odor	C Skin – dermal exposures have the potential for significant contribution to overall dose[AC].
Trichlorobenzene (1,2,4-) 120-82-1	1.4 [0.18]	D	Irritation eyes, skin, mucous membranes; liver, kidney damage, possible teratogen.	Liver, eyes, skin, URS, REPR	24 Aromatic odor	
Trichloroethane (1,1,2-) 79-00-5	0.30 [0.055]	C	Irritation, eyes, nose; CNS depression; liver, kidney damage; dermatitis, cancer.	Liver, eyes, URS, CNS, kidneys	NA	C

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Trichlorofluoromethane 75-69-4	4.8 [0.85]	NA	Renal and respiratory effects.	Kidneys, LRS, CVS, CNS[H, Ac]	28-1170 Sweet odor	
Trichlorophenol (2,4,6-) 88-06-2	1.5 [0.19]	B2	Leukemia[I]; cancer.	Blood, HEM	Strong phenolic odor	C
Trichloro-1,2,2-trifluoroethane (1,1,2-) 76-13-1	21.0 [2.7]	NA	Irritation skin, throat; drowsiness; dermatitis; CNS depression, asphyxiation, cardiac arrhythmias, narcosis.	Skin, heart, CNS, CVS	342-1026 Sweet odor	
Triethylamine 121-44-8	0.10 [0.024]	NA	Irritation eyes, skin, respiratory system; myocardial, kidney, liver damage[N]; squamous metaplasia in the trachea, thymic atrophy, lung effects (perivascular edema), death[I].	Eyes, skin, RS, CVS, liver, kidneys	0.36-1.12 Fishy, amine odor	Skin – dermal exposures have the potential for significant contribution to overall dose[Ac]. Dermal application may cause chemical burns. Based on one study, the concentration response curve of triethylamine appears to rise abruptly, with frank effects occurring at levels only 4-fold above a no-effect level.

Chemical CAS No.	1-Year Air-MEG mg/m^3 [ppm]	Cancer Group	Potential Toxic Signs and Symptoms [S,N]	Target Organs and Systems	Odor/ Threshold[O] mg/m^3 [ppm]	Notes
Trimethylbenzene (1,2,4-) 95-63-6	3.06 [0.62]	NA	Irritation of skin, eyes, nose, throat, bronchitis, anemia, drowsiness, fatigue, nausea	Eyes, skin, RS, CNS, Blood	Distinctive aromatic odor	
Trimethylbenzene (1,3,5-) 108-67-8	3.06 [0.62]	NA	Irritation of skin, eyes, nose, throat, bronchitis, anemia, drowsiness, fatigue, nausea	Eyes, skin, RS, CNS, blood	Sweet odor	
Vinyl acetate 108-05-4	0.14 [0.039]	NA	Irritation eyes, skin, nose, throat; hoarseness, cough; loss of smell.	RS, eyes, skin	0.36-1.65 Sour, sharp odor	
Vinyl Bromide 593-60-2	0.0021 [0.00047]	B2	Irritation eyes, skin; dizziness, confusion, incoordination, narcosis, nausea, vomiting[N]; liver injury and cancer[H].	Eyes, skin, CNS, liver, GI tract[N]	Characteristic pungent odor	Bromoethene appeared carcinogenic (in liver) in this study at higher doses.
Vinyl chloride 75-01-4	0.057 [0.022]	A	Weakness; abdominal pain, GI bleeding; enlarged liver; pallor or cyanosis of extremities; Raynaud's syndrome, acroosteolysis; cancer.	Liver, CNS, RS, REPR, fetus, CVS, GI tract	[10-20] Sweet, ethereal odor	C
Xylene (mixed, o, m, p) 1330-20-7	10.6 [2.4]	NA	Irritation eyes, nose throat, CNS effects; GI distress; pulmonary inflammation /edema; reproductive and developmental effects	Eyes, URS, CNS, liver, REPR, fetus	NA	

Footnotes on next page.

FOOTNOTES FOR TABLE C-3 – LONG-TERM AIR-MEGS

Ac - ACGIH, 1999 TLVs and BEIs Handbook
BW – body weight
BAP – Benzo(a)pyrene
BUN – Blood urea nitrogen (indicator of kidney infection)
C - MEG based on carcinogenic effect
CHID – Chemical Hazard Information for Deployments. Additional Fact Sheet information is under development for notated Chemicals.
E- Critical studies identified by IRIS, HEAST or NCEA. See RD 230 for specific basis and calculations.
EKG – Electrocardiogram
H – HEAST, USEPA, 1997
I – IRIS, USEPA, 1999
LOAEL - Lowest-observed adverse-effects level
M - National Research Council, Committee on Toxicology. 1997, *Toxicity of Military Smokes and Obscurants*, National Academy Press, Washington, D.C
N - National Institute of Safety and Occupational Health (NIOSH) Pocket Guide to Chemical Hazards, 1994, and IRIS/HEAST (unless noted)
NA - Not Available; for cancer class an NA is sometimes assumed to be a "non-carcinogen" but specific studies may not have been performed
ND - Not Determined
NOAEL - No-observed adverse effects level
NOEL - No-observed effects level
Ns - National Safety council, 1988, *Fundamentals of Industrial Hygiene*
O - The primary sources of odor thresholds in air were the *Odor Thresholds and Irritation Levels of Several Chemical Substances: A Review*, American Industrial Hygiene Association J., 47, 1986 and the N.J. Hazardous Substances Fact Sheets. Ranges represent reported low and high threshold ranges. Significant figures are reported as provided in sources. The primary sources of odor characteristics were Amer. Ind. Hyg. Assoc. J (47), 1086 and the Hazardous Substances Data Base.
PAH – Polyaromatic hydrocarbons
ppm – parts per million
S - Exposure symptoms which may occur at with acute or long-term exposures above Air MEGs-L
SGOT – Serum glutamic-oxaloacetic transaminase (aspartate aminotransferase)
SGPT – Serum glutamate pyruvate transaminase (alanine aminotransferase)
T - Compton, James A.F. 1987. *Military Chemical and Biological Agents*, The Telford Press, Caldwell, NJ.
TEF – Toxicity equivalence factor
UD - Under development; requires further assessment

Target Organ/Systems and Carcinogenicity information next page:

TABLE 2-4-1. TARGET ORGANS

TARGET ORGANS	
Eyes	Brain
Skin	Heart
Blood	Pancreas
Bladder	Adrenal Glands
Thyroid	Lungs
Bone	Liver
Fetus	Kidneys
Spleen	

TABLE 2-4-2. TARGET SYSTEMS

TARGET SYSTEMS	
CNS – Central Nervous System	CVS – Cardiovascular System
PNS – Peripheral Nervous System	ChE Inh – Cholinesterase Inhibitor
GI tract – Gastrointestinal Tract	UT – Urogenital Tract
RS – Respiratory System	CRC – Circulatory System
LRS – Lower Respiratory System	IMM – Immune System
URS – Upper Respiratory System	REPR – Reproductive System
ENDO – Endocrine System	HEM – Hemopoietic System
LYMP – Lymphatic System	

Cancer Class Categories:

The scheme used by the USEPA for categorizing chemicals according to their carcinogenic potential is as follows (see Section 2.4.3):

Group A: Human carcinogen
Group B: Probable human carcinogen:
- Group B1 - Limited evidence in epidemiologic al studies
- Group B2 - Sufficient evidence from animal studies

Group C: Possible human carcinogen
Group D: Not classifiable
Group E: No evidence of carcinogenicity

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TABLE C-4. AMBIENT AIR QUALITY STANDARDS AND MILITARY EXPOSURE GUIDELINES FOR PRIORITY POLLUTANTS

POLLUTANT	NAAQS (Primary)	TLV-TWA*	1 Year Air-MEG
Carbon Monoxide (CO)			
1-hour average	35 ppm (40 mg/m^3)	—	—
8-hour average	9 ppm (10 mg/m^3)	25 ppm (29 mg/m^3)	—
1-year average	—	—	3 ppm (3.3 mg/m^3)
Nitrogen Dioxide (NO_2)			
1-year average	0.053 ppm (100 µg/m^3)	—	0.053 ppm (0.1 mg/m^3)
8-hour average	—	3 ppm (5.6 mg/m^3)	—
Ozone (O_3)			
8-hour average	0.08 ppm (157 µg/m^3)	Moderate work: 0.08 ppm (0.16 mg/m^3)	—
1-year average	—	—	0.027 ppm (0.052 mg/m^3)
Lead			
8-hour average	—	0.05 mg/m^3 [A] 0.03 mg/m^3 [B]	—
3-month Average	1.5 µg/m^3	—	—
1-year average	—	—	0.0015 mg/m^3
Particulate < 10 ? m (PM-10) †			
8-hour average	—	10 mg/m^3	—
24-hour[C]	150 µg/m^3	—	—
1-year average	50 µg/m^3	—	0.07 mg/m^3
Particulate < 2.5 ? m (PM-2.5) †			
8-hour average	—	3 mg/m^3	—
24-hour[D]	65 µg/m^3	—	—
1-year average	15 µg/m^3	—	0.04 mg/m^3
Sulfur Dioxide (SO_2)			
3-hour average	0.50 ppm (1300 µg/m^3)	—	—
8-hour average	—	2 ppm (5.24 mg/m^3)	—
24-hour average	0.14 ppm (365 µg/m^3)	—	—
1-year average	0.03 ppm (80 µg/m^3)	—	0.05 ppm (0.13 mg/m^3)

ppm= Parts per Million

* The American Conference of Industrial Hygienists (ACGIH) time-weighted average (TWA) concentration for a conventional 8-hr workday and a 40-hr workweek, to which it is believed that nearly all workers may be repeatedly exposed, day after day, without adverse effect.

† See Table C5 (next page) for additional information.

[A] This is also the OSHA 8-hr permissible exposure limit (PEL) (29 CFR 1910.1025)

[B] OSHA action level (29CFR 1910.1025). For those workers exposed to air concentrations at or above the action level for more than 30 days, OSHA mandates periodic determination of blood lead levels.

[C] Three-year average of the 99th percentile of 24-hour concentrations over a given year, with one or less days exceeded.

[D] Three-year average of the 98th percentile of 24-hour concentrations over a given year, with one or less days exceeded.

For reference, the USEPA general population index values for particulates are provided below. The user should note that these values do not portray exactly the same levels of risk represented by the MEGs in this Appendix. The index ranges are only provided to make relative comparisons to U.S. guidance regarding recommended activity levels for different levels of air quality.

TABLE C-5. U.S. GENERAL POPULATION INDEX CRITERIA FOR PARTICULATE MATTER (PM_{10})*

Level	Concentration (?g/m^3)	General Civilian Population Health Effects Statements	General Civilian Population Health Effects Statements
1	255-354	Increased respiratory symptoms (e.g. coughing) and aggravation of lung disease (e.g., asthma)	Elderly, children, and people with lung disease (e.g., asthma) should restrict heavy exertion; others should minimize prolonged exertion
2	355 - 424	Significant increase in respiratory symptoms (e.g. coughing, mucous) and aggravation of lung disease (e.g. asthma)	Elderly, children, and people with lung disease (e.g., asthma) should avoid outdoors; others should minimize moderate to heavy exertion
3	425 - 604	Serious risk of respiratory symptoms (e.g. coughing, mucous, shortness of breath) and aggravation of lung disease (e.g. asthma)	All should minimize outdoor exertion

* U.S. Environmental Protection Agency, Guideline for Reporting of Daily Air Quality –Pollutant Standards Index (PSI) DRAFT, 1998.

CHEMICAL INDEX (AIR)

APPENDIX D

MILITARY EXPOSURE GUIDELINES FOR WATER

CONTENTS

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TABLE D-1. SHORT-TERM, WATER MILITARY EXPOSURE GUIDELINES (5 AND 14 DAYS)

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Acifluorfen 5094-66-6	2.8	2.8	0.9	0.9	Liver changes.	Liver	NA	B carcinogen
Acrylamide 79-06-1	2	0.4	.7	0.14	Sleepiness, hallucinations, disorientation, incoordination in the legs, weakness, tremors, and possibly seizures.	CNS, PNS	NA	Effects of high exposure may be delayed in onset for several hours. B carcinogen
Acrylonitrile 107-13-1	0.5	0.5	0.14	0.14	Headache, irritability, light-headedness, impaired judgment, nausea, vomiting, diarrhea, abdominal pain, weakness; higher concentrations may cause liver damage, anemia, irregular breathing, and seizures; exposure in utero may cause birth defects.	CVS, liver, kidneys, CNS, REPR	NA	Ingestion of 1.5 to 2 g (300-400 mg/L) can cause severe, lasting effects. Based on ATSDR MRL. B carcinogen
Adipate (diethylhexyl) 103-23-1	28	28	9.3	9.3	Short-term effects from exposure in drinking water are unknown.	Liver, REPR	NA	C carcinogen.
Alachlor 15972-60-8	0.14	0.14	0.05	0.05		Liver, kidney, spleen	NA	B human carcinogen.
Aldrin 309-00-2	0.0004	0.0004	0.0001	0.0001	Nausea, vomiting, diarrhea, hyperexcitablity, tremors, limb jerks, convulsions, and ventricular fibrillation; reversible kidney and liver injury.	CNS, liver, kidneys	Odor: 0.017 mg/L	Ingestion of 25.6 mg/kg (360 mg/L) can produce convulsions; a single oral dose of 5 g (1 g/L) was lethal. B carcinogen.
Ametryn 834-12-8	12	12	4	4	Incoordination, shortness of breath, muscle weakness, salivation, and loss of reflexes.	Liver, CNS	NA	
Ammonia 7664-41-7	3.4	3.4	3.4	3.4	Very high concentrations are corrosive and can cause ulcerative esophagitis. Such levels are not		Odor and taste: 3.4 mg/L	Exposure guideline for ammonia based on odor and taste threshold; can

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
					likely to be found in drinking water.			react with the water supply disinfectant hypochlorite to produce objectionable tastes and odors.
Ammonium sulfamate 7773-06-0	90	90	30	30	Gastrointestinal disturbances.	GI tract	NA	A military adjustment factor of 3 has been applied.
Antimony 744-36-0	0.006	0.006	0.002	0.002	Irritation of the nose, mouth, nose and intestines; nausea, vomiting, diarrhea, bloody stools, stomach cramps, difficulty breathing, weight and hair loss, dry scaly skin; heart, liver, and kidney congestion.	GI tract, CVS, liver, kidney	NA	Doses between 1 and 1.5 mg/kg (14-21 mg/L) may cause severe vomiting, diarrhea and death.
Arsenic 7440-38-2 ***TB MED 577**	0.3	-	0.1	-	Facial swelling, vomiting, loss of appetite, abdominal pain; diarrhea, shock, muscle cramps, headache, chill, cardiac abnormalities, anemia, decreased white blood cell count, and enlargement of liver; delayed effects include sensory and motor peripheral polyneuropathies.	Liver, kidney, CRC, CNS, GI tract, IMM	NA	The risk of developing symptoms of acute toxicity increases as the concentration in drinking water increases above 0.3 mg/L. The risk of severe toxic effects and fatalities increases as concentrations rise above 14 mg/L. Known human carcinogen. CHID under development.
Atrazine 1912-24-9	0.7	0.7	0.23	0.23	Congestion of heart, lungs and kidneys; hypotension, urine retention, muscle spasms, loss of appetite, salivation, depression of activity, incoordination, fever, and shortness of breath.	Eyes, CNS, CVS	NA	Possible human carcinogen. Atrazine values were adjusted in accordance with the 4/01/97 IRIS.[I]

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Baygon 114-26-1	0.06	0.06	0.02	0.02	Headache, constricted pupils, blurred vision, nausea, vomiting, abdominal cramps, diarrhea, salivation, sweating, tearing, runny nose, lassitude, weakness, chest tightness, loss of coordination, slurred speech, muscle twitching, breathing difficulty, and incontinence; higher concentrations can cause convulsions and coma; fetal death and birth defects have been observed in experimental animals.	CNS, GI tract, ChE Inh.	NA	A single oral dose of 0.36 mg/kg (5 mg/L) caused transient stomach discomfort, blurred vision and sweating. Ingestion of a single oral dose of 1.5 mg/kg (21 mg/L) caused blurred vision, nausea, sweating, rapid heartbeat, and vomiting. The effects occurred within 15-20 minutes after exposure and disappeared within 2 hours. C carcinogen.
Bentazon 25057-89-0	0.4	0.4	0.1	0.1	Vomiting, diarrhea, difficulty breathing, weakness, apathy, incoordination, and tremors.	CNS	NA	
Benzene 71-43-2	0.3	0.3	0.1	0.1	Vomiting, loss of coordination, light-headedness, headache, anemia, shallow/rapid pulse, loss of concentration, delirium, chemical pneumonitis, dizziness, pallor, flushing, weakness, and breathlessness; high concentrations may cause convulsions, coma, or irregular heart beat.	Eyes, skin, RS, blood, CNS, bone, IMM	Odor: 2.0 mg/L Taste: 0.5 - 4.5 mg/L	The mean lethal dose has been estimated to be 13 g (2.6 g/L). Known human carcinogen. CHID under development.

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Beryllium 7440-41-7	36	36	12	12	Low acute toxicity by ingestion.	Bone	NA	B carcinogen.
Boron 7440-42-8	5	1.2	1.7	0.4	Vomiting, abdominal pain, diarrhea; headache, tremors, restlessness, weakness, convulsions; may affect the liver, and may cause skin rash and desquamation.	CNS, skin, kidneys	NA	Single ingestion of 1.8 to 3.6 mg/kg (25-50 mg/L) boron caused no effects in volunteers. Ingestion of 22.5 mg/kg (315 mg/L) produced erythema, desquamation, and CNS effects. The mean lethal oral dose has been estimated to be over 400 mg/kg (5.6 g/L) in humans and the lowest oral lethal dose has been estimated as 112 mg/kg (1.6 g/L). USEPA and state (long-term) standards 0.6-1.0 mg/L.
Bromacil 314-40-9	7	7	2	2	Vomiting, salivation, muscular weakness, excitability, diarrhea, and mydriasis.	Thyroid	NA	C carcinogen.
Bromochloromethane 74-97-5	1.4	1.4	0.5	0.5	Loss of appetite, nausea, vomiting, abdominal pain, severe headache, confusion, dizziness, memory impairment, weakness, tremors and convulsions; elevated carboxyhemoglobin.	Liver, kidneys, CNS	Odor: 34 mg/L	B carcinogen (kidney and liver tumors). Long-term USEPA and State standards range 0.08 – 0.002 mg/L
Bromodichloro-methane 75-27-4	8.4	8.4	2.8	2.8	CNS functional disturbances, including sedation, anesthesia, incoordination, and depression of rapid eye movement sleep; increased blood levels of	CNS, liver, kidneys	NA	B carcinogen.

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
					methemoglobin. Liver, kidney tumors in animals.			
Bromoform 75-25-2	7	3	2	1	Headache, dizziness, disorientation, listlessness, amnesia and slurred speech, shock, unconsciousness, and convulsions.	CNS, liver, kidneys	NA	Probable human carcinogen.
Bromomethane 74-83-9	0.2	0.2	0.07	0.07	Tremor, convulsions, shortness of breath.	CNS	NA	
Butylate 2008-41-5	3	3	1	1			NA	
BZ 6581-06-2 ***TB MED 577**	0.007	-	0.0023	-	Elevated heart rate and blood pressure, facial flushing, dryness of the throat and mouth, loss of appetite, weakness, fatigue, and blurred vision; higher concentrations may cause tremors of the lips and arms, facial muscle twitches, speech difficulties, severe mental depression, and confusion.	CNS	NA	The risk of severe and enduring performance-degrading effects increases as the concentration of BZ in drinking water increases above 0.007 mg/L. Concentrations of 0.014 mg/L can cause blurred vision, dry mouth and mild incapacitation; 0.028 mg/L may cause delirium.
Cadmium 7440-43-9	0.06	0.06	0.02	0.02	Nausea, vomiting, diarrhea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock, and renal failure.	Kidneys, liver	NA	Ingestion of 3 mg (0.6 mg/L) may cause vomiting; 30 mg (6 mg/L) of soluble cadmium salts can produce severe toxic symptoms; 350 mg (70 mg/L) may be fatal.

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Carbaryl 63-25-2	1.4	1.4	0.5	0.5	Nausea, vomiting, abdominal cramps, diarrhea, salivation, sweating, lassitude, weakness, runny nose, chest tightness, blurred or dim vision, miosis, tearing, loss of coordination, slurred speech, muscle twitching, tremor, breathing difficulty, cyanosis, hypertension, jerky movements, incontinence, convulsions, coma, and respiratory paralysis.	CNS, REPR, CVS, ChE Inh	NA	Single doses of 0.5 to 2.0 mg/kg (7 -28 mg/L) and repeated daily doses of 0.13 mg/kg (1.82 mg/L) taken for 6 weeks caused no adverse effects in volunteers. But ingestion of single doses of 2.8 mg/kg (39 mg/L) or 5.45 mg/kg (76 mg/L) produced moderately severe poisoning with vomiting, pain and lassitude in other individuals; 5.7 g/kg (80 g/L) has been fatal.
Carbofuran 1553-66-2	0.07	0.07	0.02	0.02	Headache, weakness, nausea, light-headedness, miosis, blurred vision, abdominal cramps, excessive perspiration and salivation, diarrhea, vomiting, muscle twitching, incoordination, and convulsions.	PNS, ChE Inh	NA	A single dose of 0.05 mg/kg (0.7 mg/L) caused no symptoms in volunteers; 0.1 mg/kg (1.4 mg/L) caused headache and light headedness; 0.25 mg/kg (3.5 mg/L) produced salivation, abdominal pain, drowsiness, dizziness, anxiety and vomiting.
Carbon disulfide 75-15-0	0.14	0.14	0.05	0.05	Dizziness, headache, nausea, vomiting, diarrhea, fatigue, palpitations and weakness; high concentrations may cause psychosis, tremor, delirium, coma, muscle spasm,	CNS, PNS, liver, REPR	NA	MEGs were derived from the ATSDR acute oral MRLs.

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
					convulsions, difficulty breathing, and liver damage.			
Carbon tetrachloride 56-23-5	5.6	0.2	2	0.07	Nausea, vomiting, abdominal pain, diarrhea, headache, drowsiness, dizziness, weakness, blurred vision, incoordination, confusion, disorientation, anesthesia, and tremors; liver and kidney damage.	CNS, liver, kidneys	Odor: 0.52 mg/L	A single oral dose of 3 ml (1 g/L) caused dizziness and a dose of 6 ml (2.0 g/L) caused sleepiness, giddiness, and headache in volunteers. Doses in excess of 500 mg/kg (7 g/L) have been reported to cause nausea, vomiting, abdominal pain, CNS and liver damage. But some individuals have suffered severe adverse effects from ingestion of 34 mg/kg (480 mg/L). Consumption of alcohol strongly exacerbates the effects of carbon tetrachloride. B carcinogen.
Carboxin 5234-68-4	1.4	1.4	0.5	0.5	Depression, difficulty breathing, seizures.	CNS	NA	
Chloral hydrate 302-17-0	1	0.3	0.3	0.1	Light-headedness, malaise, deep stupor, incoordination, and nausea; occasional vomiting, flatulence, stomach ulcers; respiratory depression and hypotension; large doses may cause cardiac arrhythmia.	CNS, GI tract, CVS, liver, kidneys	NA	C carcinogen.

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Chloramben 133-90-4	3.5	3.5	1.2	1.2	Skin or eye contact may cause irritation.		NA	
Chlordane 57-74-9	0.09	0.09	0.03	0.03	Nausea, vomiting, diarrhea, headache, excitability, confusion, weakness, incoordination; high concentrations may cause delirium, muscle spasms, convulsions or seizures, coma, pulmonary edema, and difficulty breathing.	CNS, liver, kidneys	NA	Ingestion of 28 to 56 mg/kg (390-780 mg/L) may cause severe effects such as convulsions. The fatal human dose lies between 6 and 60 gm (1 and 10 g/L). The onset of symptoms occurs 45 minutes to several hours after ingestion. B carcinogen.
Chloride 16887-00-6 ***TB MED 577**	600	600	600	600	Reduced water consumption due to high chloride concentrations can lead to dehydration, with symptoms including weariness, apathy, impaired coordination, delirium, heat stroke.		NA	Exposure guidelines are based on palatability; at 600 mg/L, 2% of the military population might refuse to drink water and may suffer dehydration; at 1,000 mg/L, 10% would be at risk of dehydration.
Chlorobenzene 108-90-7	3	3	1	1	Drowsiness, dizziness, light-headedness, muscle spasms, and coma; impaired liver and kidney function.	CNS, liver, kidneys	Odor: 0.05 mg/L Taste: 0.010 - 0.02 mg/L	
Chlorodibromo-methane 124-48-1	8.4	8.4	2.8	2.8	Incoordination, depression of rapid eye movement, sleep, sedation, anesthesia, increased blood levels of methemoglobin; injury of the liver, kidneys and adrenals.	CNS, liver, kidneys	NA	C carcinogen.

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Chloroisopropyl ether (bis-2-) 108-60-1	5.6	5.6	2	2			Odor: 0.2 - 0.32 mg/L	
Chloroform [Tricloromethane] 67-66-3	6	6	2	2	Dizziness, mental dullness, headache, nausea, confusion, fatigue, narcosis, liver and kidney damage/cancer; renal necrosis.	Kidneys, CNS, bladder, fetus	NA	B2 carcinogen; long-term USEPA MCL = 0.0mg/L
Chloromethane [Methyl chloride] 74-87-3	12	0.5	4	0.17	Headache, drowsiness, giddiness, dizziness, confusion, incoordination, vomiting, abdominal pain, diarrhea, breathing difficulties; high concentrations may cause unconsciousness, convulsions, coma, visual disturbances, and may damage the kidneys, liver, or blood.	CNS, liver, kidneys, REPR	NA	Symptoms of chloromethane exposure may be delayed in onset. C carcinogen.
Chlorophenol (2-) 95-57-8	0.8	0.8	0.3	0.3	Restlessness, rapid breathing, and muscle weakness, followed by tremors, seizures, and coma.	CNS, liver, kidneys	Odor: 0.0001 mg/L	Can react with the water supply disinfectant hypochlorite to produce objectionable tastes and odors.
Chlorothalonil 1897-45-6	0.35	0.35	0.12	0.12	Vomiting, rapid breathing, gastrointestinal irritation, weakness, and sedation.	CNS, GI tract, UT	NA	B carcinogen.
Chlorotoluene o- 95-49-8	2.8	2.8	0.9	0.9			Odor: 0.0069 mg/L	
Chlorotoluene p- 106-43-4	2.8	2.8	0.9	0.9			NA	

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Chlorpyrifos 2921-88-2	0.04	0.04	0.014	0.014	Headache, fatigue, dizziness, mental confusion, disorientation, tearing, salivation; cyanosis, constricted pupils, blurred vision, weakness, nausea, vomiting, abdominal cramps, diarrhea, muscle spasms and twitching, convulsions, coma, loss of reflexes, and incontinence. May possibly cause delayed peripheral neuropathy and birth defects.	CNS, PNS, ChE Inh	NA	A single oral dose of 0.5 mg (0.1 mg/L) caused a 15% depression of plasma cholinesterase and no signs of toxicity in volunteers. Ingestion of 0.1 mg/kg/day (1.4 mg/L) for 9 days depressed plasma cholinesterase and had no other effects in volunteers; 0.03 mg/kg/day (0.42 mg/L) for 20 days caused no significant effects. Ingestion of 300 mg (60 mg/L) caused loss of consciousness and acute signs of cholinergic toxicity followed by long-term neurologic effects.
Chromium (total) 7440-47-3	2	2	0.7	0.7	Hexavalent chromium compounds are more toxic than trivalent chromium compounds; ingestion of hexavalent chromium compounds may cause intense gastrointestinal irritation, violent epigastric pain, nausea, vomiting, diarrhea, bleeding, circulatory collapse, unconsciousness, and death; liver and kidney damage are possible with large exposures.	Kidneys, liver	NA	Doses of 0.5 to 1.5 g (100 - 300 mg/L) have caused fatalities.
Cyanazine 21725-46-2	0.14	0.14	0.05	0.05	Weakness, nausea and difficulty breathing; may affect kidney	Blood, kidneys	NA	C carcinogen.

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
					function. Birth defects have been observed in the offspring of experimental animals.			
Cyanide 57-12-5 ***TB MED 577**	6	6	2	2	Headache, breathlessness, weakness, palpitation, nausea, vomiting, giddiness, tremor, rapid heart beat, dizziness, confusion, anxiety, agitation, confusion, cardiac arrhythmias, seizures, stupor, and coma.	CNS, RS, CVS, liver, kidneys	NA	Concentrations between 12 and 24 mg/L may cause changes in blood chemistry without clinical effects. Severe but reversible symptoms may occur at concentrations of 24 to 48 mg/L; concentrations higher than 48 mg/L cause life-threatening toxicity.
2,4-D (2,4-Dichlorophenoxy-acetic acid) 94-75-7	1.5	0.4	0.5	0.14	Nervous system damage, vomiting, diarrhea, lethargy, incoordination, weakness, paralysis, stupor, miosis, stiffness in the extremities, muscle twitching and spasms, lowered blood pressure, convulsions; transient liver and kidney damage; may cause birth defects and reduced fertility.	CNS, liver, kidneys	NA	Ingestion of a single dose of 5 mg/kg (70 mg/L) and repeated doses of 7 mg/kg/day (98 mg/L) for 21 days caused no effects. The single oral lethal dose has been estimated to be 355 mg/kg (5 g/L). Survival following a dose of about 110 mg/kg (1.5 g/L) has been reported.
Dalapon 75-99-0	4.2	4.2	1.4	1.4	CNS depression, lassitude, loss of appetite, diarrhea, vomiting, slowing of pulse.	GI tract, CNS	NA	

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
DCPA [Dacthal] 1861-32-1	105	105	35	35				Single oral doses of 50 mg (10 mg/L) caused no observable effects in volunteers.
Diazinon 333-41-5	0.03	0.03	0.009	0.009	Nausea, vomiting, diarrhea, headache, dizziness, weakness, excessive tearing and salivation, ocular pain, blurring/ dimness of vision, miosis, loss of muscle coordination, slurred speech, muscle twitching, disorientation, drowsiness, difficulty breathing, hypertension, hypotension, cardiac arrhythmias, random jerky movements, incontinence, convulsions, and coma.	Eyes, RS, CNS, CVS, blood, ChE Inh		
Dibromoacetonitrile 3252-43-5	2.8	2.8	0.94	0.94				C carcinogen.
Dibromochloro-propane 96-12-8	0.28	0.07	0.09	0.024	Gastrointestinal distress; may damage the kidney, liver, and testes.	Liver, kidneys, spleen, REPR, GI tract, CNS	Odor: 0.01 - 3.1 mg/L	
Dicamba 1918-00-9	0.4	0.4	0.14	0.14	Vomiting, loss of appetite, headache, dizziness, weakness, difficulty breathing, muscle weakness and spasms.	CNS	NA	
Dichloroacetic acid 79-43-6	1.5	1.5	0.5	0.5	Decreased plasma lactate and glucose levels; high concentrations may cause birth defects.	REPR	NA	B carcinogen.

Chemical CAS No.	5 L/day MEG † (mg/L)		15 L/day MEG † (mg/L)		Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
	5-day	2-week	5-day	2-week				
Dichloroacetonitrile 3018-12-0	1.4	1.4	0.5	0.5	Nausea, vomiting, weakness, stupor, convulsions, and delirium; liver and kidney damage.	CVS, CNS, liver, kidneys	NA	C carcinogen.
Dichlorobenzene m- 541-73-1	12.6	12.6	4.2	4.2	Headache, drowsiness, unsteadiness; irritation of gastric mucosa, nausea, vomiting, diarrhea, abdominal cramps and cyanosis.	CNS, liver, kidneys	NA	
Dichlorobenzene o- 95-50-1	12.6	12.6	4.2	4.2	Headache, nausea, vomiting, and diarrhea; higher doses can produce dizziness, sleepiness, loss of coordination and judgment; methemoglobinemia, hemolytic anemia, and kidney damage.	Liver, kidneys, CNS	NA	
Dichlorobenzene p- 106-46-7	15	15	5	5	High concentrations may cause nausea, vomiting, headaches, liver and kidney injury, anemia, and jaundice.	Liver, kidneys, CNS	NA	C carcinogen.
Dichlorodifluoro-methane 75-71-8	60	60	20	20	Relatively non-toxic by ingestion.	CNS, CVS	NA	The systems listed under target organs are those known to be affected by inhalation.
Dichloroethane (1,2-) 107-06-2	1	1	0.3	0.3	Headache, dizziness, drowsiness, cyanosis, nausea, vomiting and diarrhea; high concentrations can cause gastrointestinal disorders, transient kidney damage, liver injury, and reduced blood pressure.	Kidneys, liver, CNS, CVS	Odor: 29 mg/L; Taste: 29 mg/L	Ingestion of 20 – 50 ml (5 to 12.6 g/L) can cause severe neurological effects and may be fatal. B carcinogen.
Dichloroethylene (1,1-) 75-35-4	2.8	1.4	1	0.5	Dizziness, headache, nausea, liver and kidney dysfunction.	Liver, kidneys, CNS	NA	C carcinogen.
Dichloroethylene (cis-1,2-)	5.6	4.5	2	1.5	CNS depression, decreased red blood cell count.	CNS, blood	NA	The trans form is approximately twice as

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
156-59-2								potent as the cis form in its depression of the CNS.
Dichloroethylene (trans-1,2-) 156-60-5	28	2	9.4	0.7	CNS depression, difficulty breathing, incoordination, decreased red blood cell count.	CNS, blood	NA	The trans form is approximately twice as potent as the cis form in its depression of the CNS.
Dichloromethane [Methylene chloride] 75-09-2	14	2.8	5	1	Dizziness, sleepiness, fatigue, weakness, light-headedness, numbness, tingling in limbs.	CVS, CNS, blood	NA	B carcinogen.
Dichlorophenol (2,4-) 120-83-2	0.04	0.04	0.01	0.01	Abdominal pain, vomiting, bloody diarrhea; pallor, sweating, weakness, headache, dizziness; possibly fleeting excitement and confusion, tremors, convulsions, unconsciousness; dark-colored urine, kidney damage, methemoglobinemia and hemolytic anemia.	CNS, liver, kidneys	NA	
Dichloropropane (1,2-) 78-87-5	0.13	0.13	0.04	0.04	Headache, dizziness; damage to the liver, kidneys, adrenal glands, bladder, and the gastrointestinal tract; hemolytic anemia.	Liver, kidneys, GI tract	NA	B carcinogen.
Dichloropropene (1,3-) 542-75-6	0.042	0.042	0.014	0.014	Weakness, headache, dizziness, lethargy, incoordination, and depressed respiration; may damage the lungs, liver, and kidneys and cause lesions in the gastrointestinal tract.	RS, CNS, liver, kidneys, GI tract	NA	B carcinogen.
Dieldrin 60-57-1	0.0007	0.0007	0.00023	0.00023	Early signs of toxicity are headache, dizziness, nausea, vomiting, malaise, sweating, tremors, limb jerks, EEG changes, convulsions, and coma; secondary	CNS	Odor: 0.04 mg/L	No effects were seen in volunteers given doses of 0.21 mg (0.04 mg/L). Serious effects may occur at a dose of 10 mg/kg

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
					effects include hypertension, cardiac arrhythmias, and fever; sleep, memory, behavioral disturbances, headache, and convulsions may persist for months following exposure.			(140 mg/L); 29 mg/kg (420 mg/L) caused profuse vomiting or prolonged convulsions; the acute mean lethal dose for humans has been estimated to lie between 20 and 70 mg/kg (280 to 980 g/L). B carcinogen.
Di(2-ethylhexyl) phthalate 117-81-7	14	14	4.7	4.7	Mild gastrointestinal disturbances, nausea, dizziness; may cause birth defects.	CNS, liver, REPR	NA	A single dose of 10 g (2 g/L) caused mild gastric disturbances and catharsis. B carcinogen.
Diisopropylmethyl-phosphonate [DIMP] 1445-75-6	30	30	10	10	High concentrations may cause lethargy and other signs of CNS depression.	CNS	NA	A military adjustment factor of 3 has been applied.
Dimethrin 70-38-2	16.8	16.8	5.5	5.5	Drowsiness, dizziness, headache, nausea, vomiting, diarrhea, gastritis, loss of appetite, fatigue, and weakness.	CNS, liver, GI tract	NA	
Dimethyl methyl phosphonate 756-79-6	2.5	2.5	0.8	0.8	High concentrations may cause lethargy and other signs of CNS depression.	CNS	NA	C carcinogen.
Dinitrobenzene (1,3-) 99-65-0	0.06	0.06	0.02	0.02	Methemoglobinemia associated with headache, irritability, dizziness, weakness, nausea, lethargy, shortness of breath, liver damage.	Blood, liver, CNS, CVS	NA	The lethal dose has been estimated to lie between 5 and 50 mg/kg (70 and 700 mg/L).
Dinitrotoluene (2,4-) 121-14-2	0.6	0.6	0.2	0.2	Methemoglobinemia with symptoms of nausea, vomiting,	Blood, CNS, testes	NA	Consumption of alcohol may exacerbate the

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
					headache, weakness, dizziness, and drowsiness; high concentrations may cause difficulty breathing, hypotension, arrhythmia, damage to liver and testes, and anemia; exposure may affect developing fetus.			toxicity of dinitrotoluene. B carcinogen.
Dinitrotoluene (2,6-) 606-20-2	0.6	0.6	0.2	0.2	Methemoglobinemia with symptoms of nausea, vomiting, headache, weakness, dizziness, and drowsiness; high concentrations may cause difficulty breathing, hypotension, arrhythmia, damage to liver and testes; exposure may affect fetus.	Blood, CNS, REPR	NA	Consumption of alcohol may exacerbate the toxicity of dinitrotoluene. B carcinogen.
Dinoseb 88-85-7	0.42	0.42	0.14	0.14	Nausea, vomiting, abdominal pain, marked thirst, fatigue, sweating, facial flushing, rapid heart beat, hyperthermia, respiratory distress, cyanosis, restlessness, anxiety, muscle cramps, excitement, convulsions, and coma.	CNS, REPR	NA	
Dioxane (1,4-) 123-91-1	5.6	0.56	2	0.2	Nausea, headache, liver and kidney damage.	Liver, kidneys, CNS	NA	B carcinogen.
Diphenamid 957-51-7	0.4	0.4	0.13	0.13	Vomiting, salivation, incoordination, prostration, spasms and convulsions.	CNS, liver	NA	
Diphenylamine 122-39-4	1.6	1.6	0.6	0.6	Fast pulse, hypertension, methemoglobinemia, bladder injury; may cause birth defects.	CVS, bladder, REPR	NA	

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Disulfoton 298-04-4	0.014	0.014	0.005	0.005	Headache, loss of appetite, nausea, vomiting, abdominal cramps, diarrhea, weakness, dizziness, confusions, slurred speech, salivation, tearing, profuse sweating, shortness of breath, tightness of the chest, changes in heart rate, cyanosis, miosis, blurred vision, runny nose, slow pulse, muscle twitching, tremors, muscle cramps, incoordination, convulsions, coma, and shock.	Eyes, RS, CNS, CVS, ChE Inh	NA	Oral doses of 0.75 mg/day (0.15 mg/L) for 30 days produced no significant effects in volunteers. The human LD_{50} has been estimated to be 5 mg/kg (70 mg/L).
Dithiane (1,4-) 505-29-3	0.5	0.5	0.2	0.2	Incoordination, lacrimation, lethargy, diarrhea.	GI tract, CNS	NA	
Diuron 330-54-1	1.4	1.4	0.5	0.5	Diuretic effects; high concentration may cause CNS depression; has caused birth defects and fetal deaths in experimental animals.	Blood, CNS	NA	
EA 2192	0.015	-	0.005	-	Nausea, vomiting, diarrhea, cramps, headache, giddiness, dizziness, excessive salivation, tearing, miosis, blurred or dim vision, difficulty breathing, cardiac arrhythmias, loss of muscle coordination, muscle twitching, random jerking movements, convulsions, coma.	CNS, ChE Inh	NA	EA 2192 is a breakdown product of VX. Because its toxicity is believed to be similar (within order of magnitude) to that of VX, the TB MED577 standard for VX was applied to EA 2192 (USACHPPM, 1999).
Endothall 145-73-3	1.1	1.1	0.4	0.4	Hypotension, depressed breathing and heart rate, vomiting, diarrhea, dilated pupils, loss of coordination, transient excitation	CNS	NA	Ingestion of 100 mg/kg (1.4 g/L) can be fatal.

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
					followed by general depression, sluggishness, spasmodic twitching, seizures.			
Endrin 72-20-8	0.035	0.02	0.01	0.007	Headache, dizziness, nausea, vomiting, hypersalivation, insomnia, lethargy, weakness, agitation and confusion; high concentrations may cause convulsions, stupor, tremors, and coma; headache, dizziness, sleepiness, weakness, and loss of appetite may persist for 2 to 4 weeks.	CNS	NA	Convulsions may be induced in humans by doses of 0.2 to 0.25 mg/kg (2.8 to 3.5 mg/L); a dose of 1 mg/kg (14 mg/L) can induce repeated seizures.
Epichlorohydrin 106-89-8	0.2	0.2	0.07	0.07	Nausea, vomiting, abdominal pain, skin irritation; muscular relaxation or paralysis, tremor, convulsions; liver and kidney damage, cyanosis, impairment of male fertility and/or spermatogenesis.	Kidneys, liver, CNS, skin, REPR	Odor: 0.5 – 3 mg/L	B carcinogen.
Ethyl benzene 100-41-4	45	4.5	15	1.5	Headache, nausea, weakness, dizziness, sleepiness, fatigue, loss of coordination, and coma.	CNS	Odor: 0.062 mg/L; Taste: 0.025 mg/L	
Ethylene dibromide 106-93-4	0.01	0.01	0.004	0.004	Liver and kidney damage, vomiting, excitement and other CNS effects.	CNS, liver, kidneys, REPR	NA	A single oral dose of 65 mg/kg (900 mg/L) may be lethal. B carcinogen.
Ethylene glycol 107-21-1	26	8	9	2.5	Weakness, dizziness, inebriation, stupor; high concentrations may cause convulsions, coma, hypertension, rapid breathing, rapid heartbeat, and severe kidney	CNS, CVS, kidneys	NA	Doses up to 190 mg/kg (2.6 g/L) produced no adverse effects in one individual. In other individuals, single doses

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
					damage.			of 1000 mg/kg (14 g/L) produced CNS effects including visual disturbances, light-headedness, headache and lethargy. Doses of 3000 mg/kg (42 g/L) caused ataxia, sleepiness disorientation and stupor, slurred speech, and in some cases, were fatal. The mean lethal oral dose is about 110 g (22.3 g/L).
ETU (Ethylene thiourea) 96-45-7	0.35	0.35	0.1	0.1	Thyroid hyperplasia with changes in levels of thyroid hormones; may cause birth defects.	Thyroid, REPR, liver, IMM	NA	B carcinogen.
Fenamiphos 22224-92-6	0.013	0.013	0.004	0.004	Nausea, vomiting, abdominal cramps, diarrhea, salivation, headache, dizziness, weakness, runny nose, blurred vision, constricted pupils, incoordination, slurred speech, muscle twitches, random jerky movements, mental confusion, disorientation, drowsiness, difficulty breathing, cardiac irregularities, incontinence, convulsions, and coma.	CNS, CVS, ChE Inh	NA	
Fluometron 2164-17-2	2.1	2.1	0.7	0.7	Depression, deep rapid breathing, vomiting, coma.	CNS, blood, thyroid, liver, ChE Inh	NA	
Fluorotrichloro-methane	9.8	9.8	3.3	3.3	Transient jaundice and liver enzyme elevation.	CNS, CVS, liver	NA	Inhaled freons can affect the CNS and the heart, but

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
75-69-4								effects are less severe following ingestion.
Fonofos 944-22-9	0.03	0.03	0.009	0.009	Loss of appetite, nausea, vomiting, abdominal cramps, diarrhea, headache, dizziness, weakness, confusion, blurred vision, constricted pupils, slurred speech, profuse sweating, salivation, and runny nose; cardiac irregularities, difficulty breathing, muscle twitching, paralysis, convulsions, coma, or respiratory arrest may occur.	CNS, CVS, blood, ChE Inh	NA	
Formaldehyde 50-00-0	14	8	5	2.6	Nausea, vomiting, abdominal pain, diarrhea, lethargy, dizziness, hypotension, seizure.	GI tract, CVS	Odor: 20 mg/L; Taste: 50 ppm	The mean lethal dose is 1 to 2 oz. (4.9 – 9.8 g/L). B carcinogen.
GA [Tabun] 77-81-6 ***TB MED 577**	0.14	-	0.046	-	Nausea, vomiting, abdominal cramps, diarrhea, headache, giddiness, dizziness, weakness, excessive tearing, blurred or dim vision, miosis, loss of muscle coordination, slurred speech, muscle twitching, confusion, disorientation, drowsiness, difficulty breathing, excessive salivation, cardiac arrhythmias, random jerking movements, incontinence, convulsions, coma.	CNS, ChE Inh	NA	Human oral LD_{50} values have been estimated at 0.357-0.714 mg/kg (5-10 mg/L).
GB [Sarin] 107-44-8	0.028	-	0.0093	-	See GA.	CNS, ChE Inh	NA	Minimal effects (e.g., excessive dreaming and talking during sleep) may occur after a single dose

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
***TB MED 577**								of 0.002 mg/kg (0.03 mg/L); mild effects (e.g., anorexia, fatigue, anxiety, tightness in the chest) can occur at 0.022 mg/kg (0.31 mg/L). The lethal oral dose has been estimated to be 0.071-0.285 mg/kg (1-4 mg/L).
GD [Soman] 96-64-0 ***TB MED 577**	0.012	-	0.004	-	See GA.	CNS, ChE Inh	NA	Oral LD_{50} values have been estimated at 0.005 to 0.020 mg/kg (0.07-0.28 mg/L).
Glyphosate 1071-83-6	25	25	8	8	Vomiting, diarrhea, abdominal pain; large doses may cause hypotension, tachycardia (rapid heart rate) and palpitations.	Kidneys	NA	
Heptachlor 76-44-8	0.014	0.014	0.005	0.005	Nausea, vomiting, diarrhea, irritation of the gastrointestinal tract; higher exposures may cause liver damage, hyperexcitability, tremors, convulsions, and paralysis.	CNS, liver, GI tract	NA	A dose of 1 to 3 g (200-600 mg/L) has been estimated to cause serious symptoms in humans, especially liver impairment. B carcinogen.

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Heptachlor epoxide 1024-57-3	0.014	-	0.005	-	Apprehension, agitation, muscle twitching and spasms, tremor, incoordination, vomiting, gastrointestinal upset, abdominal pain; higher doses may cause liver damage, and convulsions.	CNS, liver	NA	B carcinogen.
Hexachlorobenzene 118-74-1	0.08	0.08	0.026	0.026	Headache, nausea, cyanosis, muscle spasm, convulsions, liver injury, birth defects.	CNS, blood, liver, kidneys	NA	B carcinogen.
Hexachlorobutadiene 87-68-3	0.4	0.4	0.14	0.14	Kidney damage, possible CNS depression.	Kidneys, liver, CNS	NA	C carcinogen.
Hexachloroethane 67-72-1	7	7	2.4	2.4	Vomiting, diarrhea, severe mucosal injury, liver necrosis, cyanosis, unconsciousness, loss of reflexes.	CNS, liver	NA	C carcinogen.
Hexane (n-) 110-54-3	18	6	5	2	Nausea, vomiting, abdominal swelling, weakness, dizziness, lightheadedness, headache, loss of coordination, damage to the peripheral nerves.	CNS, PNS	NA	About 50 g (10 g/L) may be fatal to humans.
Hexazinone 51235-04-2	10.5	10.5	3	3	Vomiting, liver injury.	Liver	NA	A military adjustment factor of 3 has been applied.
HMX 2691-41-0	7	7	2.3	2.3	Changes in the blood, methemoglobinemia, liver damage.	CNS, blood, CVS, kidneys, liver	NA	
Isophorone 78-59-1	6	6	2	2	Headache, nausea, dizziness, fatigue, incoordination, malaise, and narcosis.	CNS, liver, kidneys	NA	C carcinogen.
Isopropyl methyl-phosphonate 1832-54-8	120	120	40	40	High concentrations may cause diarrhea, reduced motor activity, lung injury.	GI tract, lungs	NA	A military adjustment factor of 3 has been applied.

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Lead compounds No specified CAS. (measured as Total Lead)	0.05	0.05	0.05	0.05	Anxiety, irritability, insomnia, lack of appetite, anemia, headache, muscle weakness, restlessness, reproductive effects in developing fetus are pronounced. Possible kidney and reproductive effects after longer chronic exposures.	CNS, fetus	NA	Primary health impacts are to children/developing fetus. But high concentrations and/or long exposures can result in health impacts to adults. MEGs were selected from general information for lead ions and compounds, including statements in the literature referenced to lead compounds, lead salts, etc. Some lead compounds (e.g. tetraethyl lead) have own unique, toxicity. This MEG should be used when assessing Total Lead analytical results. CHID under development.
Lewisite 542-25-3 ***TB MED 577**	0.08	-	0.027	-	Nausea, vomiting, diarrhea, abdominal pain, intense thirst, restlessness, weakness, hypotension, and hypothermia.	GI tract, heart, brain, kidneys	NA	The risk of potentially fatal performance-degrading injury to the gastrointestinal tract increases as the concentration in drinking water increases above 0.08 mg/L.
Lindane 58-89-9	0.6	0.6	0.2	0.2	Irritability, restlessness, insomnia, anxiety, dizziness, malaise, headache, nausea, fever, cyanosis,	CNS, REPR	NA	Increasing susceptibility to nervous system changes may occur at

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
***TB MED 577**					vomiting, and loss of muscle coordination; higher exposure can cause muscle spasms, seizures, and convulsions.			concentrations between 0.6 and 3.5 mg/L. Signs of poisoning begin to develop at 3.5 mg/L. The mean lethal dose is approximately 400 mg/kg (5.6 g/L). C carcinogen.
Magnesium 7439-95-4 ***TB MED 577**	100	100	30	30	Single doses can have laxative effects that can lead to dehydration, with symptoms of discomfort, weariness, apathy, impaired coordination, delirium and heat stroke.	GI tract	NA	Laxative effects occur at doses greater than 480 mg (96 mg/L).
Malathion 121-75-5	0.3	0.3	0.1	0.1	Miosis, blurred vision, tearing, increased salivation, weakness, nausea, vomiting, abdominal cramps, diarrhea, giddiness, confusion, loss of muscle coordination, runny nose, headache, chest tightness, difficulty breathing, pulmonary edema, muscle twitching, coma, respiratory distress, cardiac irregularities, and convulsions.	Lungs, liver, CNS, heart, ChE Inh	NA	No effects were seen in volunteers after a single oral dose of 0.84 mg/kg (11.6 mg/L) or repeated doses of 16 mg/day (3.2 mg/L) for 47 days. The fatal dose is believed to be between 350-1000 mg/kg (4.9-14 mg/L).
Maleic hydrazide 123-33-1	14	14	5	5	Tremors and muscle spasms.	CNS	NA	

Chemical CAS No.	5 L/day MEG † (mg/L)		15 L/day MEG † (mg/L)		Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
	5-day	2-week	5-day	2-week				
MCPA 94-74-6	0.14	0.14	0.05	0.05	Fatigue, weakness, loss of appetite, nausea, vomiting, diarrhea, lethargy, constricted pupils, hypotension, slurred speech, muscle twitches, random jerky movements, paralysis and convulsions; kidney and liver injury, reduced white and red blood cell counts.	CNS, kidneys, liver, blood	NA	Ingestion of 250 mg/kg (3.5 g/L) is fatal.
Methomyl 16752-77-5	0.1	0.1	0.03	0.03	Severe headache, nausea, vomiting, diarrhea, abdominal cramps, sweating, salivation, blurred vision, constricted pupils, muscle twitching, incoordination, weakness, difficulty breathing, increased heart rate; liver and kidney damage; changes in electrocardiograph patterns are possible.	CNS, CVS, liver, kidneys, ChE Inh	NA	Doses of 12-15 mg/kg (168-210 mg/L) can be fatal.
Methoxychlor 72-43-5	0.08	0.08	0.03	0.03	Muscle spasms, trembling, and convulsions; high concentrations may injure the kidney and liver.	CNS, liver, kidneys	NA	Daily doses of 2 mg/kg (28 mg/L) for 6 weeks had no adverse effects in volunteers. The fatal oral dose for humans had been estimated to be 6 g/kg (84 g/L).
Methyl tert-butyl ether 1634-04-4	33.6	33.6	11.3	11.3	Low acute toxicity by ingestion.			C carcinogen.
Methyl parathion 298-00-0	0.4	0.4	0.15	0.15	Nausea, vomiting, abdominal cramps, diarrhea, salivation, headache, weakness, giddiness, dizziness, runny nose, blurred vision, miosis, cardiac	Eyes, CNS, CVS, liver, kidneys, ChE Inh	NA	Volunteers receiving oral doses of 22 mg/day (4.4 mg/L) suffered no ill effects. Depression of red blood cell cholinesterase

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
					arrhythmias and ischemia, difficulty breathing; muscle twitch, convulsions, liver and kidney damage, coma and respiratory paralysis are possible at high concentrations.			occurred at doses of 30 mg/day (6 mg/L) which was considered to be the level of minimal toxicity. Ingestion of 50 to 200 g (10-40 g/L) has resulted in death; the minimum adult lethal dose by the oral route may be less than 1.84 g (370 mg/L).
Metolachlor 51218-45-2	3	3	1	1	Headache, nausea, vomiting, abdominal cramps, diarrhea, sweating, weakness, anemia, incoordination, CNS depression, dark urine, liver and kidney damage, jaundice, methemoglobinemia, cyanosis, hypothermia, convulsions; affect fertility.	CNS, liver, kidneys, blood	NA	C carcinogen.
Metribuzin 21087-64-9	6.3	6.3	2	2	CNS depression; thyroid, kidney and liver injury.	CNS, thyroid, kidneys, liver	NA	
Molybdenum trioxide 7439-98-7	0.03	0.03	0.009	0.009	Weight loss, diarrhea, poor muscle coordination, headaches, muscle or joint aching.	Liver, kidneys, blood	NA	
Naphthalene 91-20-3	0.74	0.74	0.25	0.25	Headache, profuse perspiration, confusion, listlessness, lethargy, muscle twitching, coma; nausea, vomiting, abdominal cramps, diarrhea; hemolytic anemia, methemoglobinemia; cataracts, liver and kidney damage.	Eyes, blood, liver, kidneys, CNS	NA	Ingestion of 1 g naphthalene (200 mg/L) caused near blindness within 9 hours. The lethal dose is about 2 g (400 mg/L).

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Nickel 7440-02-0	1	1	0.5	0.5	Soluble nickel salts may cause gastrointestinal distress, nausea, abdominal cramps, diarrhea, vomiting, giddiness, weariness, and headache; metallic nickel is generally considered not to be acutely toxic if ingested.	GI tract, CNS	NA	
Nitroguanidine 556-88-7	15	15	5	5	High concentrations may cause inactivity, incoordination, tremors, difficulty breathing, and cyanosis.	CNS	NA	
Nitrophenol p- 100-02-7	1.2	1.2	0.4	0.4	Fever, CNS depression, sweating, weakness, headache, dizziness, tinnitus, irregular pulse, hypotension, shallow respiration, cyanosis.	CNS, blood	Odor: 43.4 mg/L	
Oxamyl [Vydate] 23135-22-0	0.35	0.35	0.1	0.1	Tremors, blurred or dim vision, increased salivation, tearing, incontinence, diarrhea, abdominal cramps, nausea, vomiting, and difficulty breathing; convulsions, coma, and respiratory paralysis are possible at high concentrations; protracted malaise and weakness may persist after apparent recovery.		NA	

Chemical CAS No.	5 L/day MEG † (mg/L)		15 L/day MEG † (mg/L)		Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
	5-day	2-week	5-day	2-week				
Paraquat 1910-42-5	0.14	0.14	0.05	0.05	Abdominal cramping, nausea, vomiting, bloody diarrhea, headache, difficulty swallowing, fever, decreased blood pressure; higher concentrations can cause heart, kidney and liver injury and extensive lung damage with difficulty breathing, pulmonary fibrosis and edema; may reduce fertility in males.	Lungs, liver, kidneys, GI tract	NA	Single oral doses of 1 to 4 g (200 to 800 mg/L) have caused fatalities.
Pentachlorophenol 87-86-5	1.4	0.4	0.5	0.14	Weakness, thirst, loss of appetite, vomiting, shortness of breath, chest pain, sweating, headache, dizziness, high fever, hypotension, and gastrointestinal upset; high concentrations may cause lung, liver, and kidney damage and convulsions.	CNS, heart	Odor: 0.03 mg/L	Ingestion of 0.1 mg/kg (1.4 mg/L) caused no effects in volunteers. The minimum lethal dose was estimated to be 29 mg/kg (406 mg/L). B carcinogen.
Phenol 108-95-2	8	8	3	3	Corrosion of the mouth, throat, and stomach, pallor, nausea, vomiting, severe abdominal pain, cold sweats, cardiac arrhythmia, wide fluctuations in blood pressure, respiratory distress, reduced body temperature, circulatory collapse.	Liver, kidneys, CVS	Odor: 0.3 mg/L	Doses of about 14 mg/kg (200 mg/L) can have dangerous effects. The oral LD_{50} has been estimated to be 140 mg/kg (2 g/L). Phenol can react with the water supply disinfectant hypochlorite to produce objectionable tastes and odors.
Picloram 1918-02-01	28	28	9.4	9.4	Nausea, diarrhea, weakness, damage to the CNS.	CNS	NA	
Prometon 1610-18-0	0.2	0.2	0.07	0.07	Mild skin and eye irritant.	CNS	NA	

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Pronamide 23950-58-5	1	1	0.4	0.4	May cause cholestasis (blockage of bile flow in the liver) which can lead to liver damage.	Liver	NA	C carcinogen.
Propachlor 1918-16-7	0.7	0.7	0.24	0.24	Weakness, salivation, tremors; liver and kidney injury.	CNS, liver, kidneys	NA	
Propazine 139-40-2	1.4	1.4	0.5	0.5	Loss of appetite, depression; high concentrations may cause dizziness, cramps and difficulty breathing.	CNS, blood, liver	NA	C carcinogen.
Propham 122-42-9	7	7	2	2			NA	
RDX 121-82-4	0.14	0.14	0.05	0.05	Headache, irritability, fatigue, weakness, tremor, nausea, vomiting, dizziness, confusion, amnesia, insomnia, convulsions, liver injury.	CNS, liver	NA	C carcinogen.
Silver 7440-22-4	0.07	0.07	0.023	0.023	High concentrations may cause abdominal pain, diarrhea, vomiting, corrosion of the gastrointestinal tract, shock and convulsions.	Skin, eyes, CNS	NA	A single oral dose of 140 mg/kg (2 g/L) may be fatal.
Simazine 122-34-9	0.03	0.03	0.01	0.01	Incoordination, tremor, weakness, muscle spasms, difficulty breathing.	CNS, kidneys, liver	NA	C carcinogen.
Strontium 7440-24-6	36	36	12	12	Excess salivation, vomiting, colic, and diarrhea.	Bone	NA	
Styrene 100-42-5	30	3	10	1	Headache, fatigue, dizziness, confusion, malaise, drowsiness, weakness, unsteady gait, impaired manual dexterity, loss of concentration.	CNS	NA	C carcinogen.

Chemical CAS No.	5 L/day MEG † (mg/L)		15 L/day MEG † (mg/L)		Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
	5-day	2-week	5-day	2-week				
Sulfate 14808-79-8 ***TB MED 577**	300	300	100	100	Single doses can have laxative effects which can lead to dehydration, with symptoms of discomfort, weariness, apathy, impaired coordination, delirium.	GI tract	NA	Laxative effects occur at doses greater than 1490 mg (300 mg/L).
Sulfur mustard [HD] 505-60-2 ***TB MED 577**	0.14	-	0.047	-	Nausea, vomiting of blood, diarrhea, abdominal pain, fever, headache, cardiac arrhythmias, dizziness, malaise, loss of appetite, lethargy, convulsions, leukopenia, anemia, immunosuppression.	GI tract, CNS, blood	NA	The oral LD_{50} for humans has been estimated to be 0.7 mg/kg (9.8 mg/L). A carcinogen.
2,4,5-T [Trichlorophenoxy-acetic acid] 93-76-5	1	1	0.4	0.4	Chloracne, nausea, headache, fatigue, muscular aches and pains; may affect the developing fetus.	Skin, REPR	NA	The only symptom reported after ingestion of 5 mg/kg (70 mg/L) was a metallic taste in the mouth.
T-2 toxin 21259-20-1 ***TB MED 577**	0.026	-	0.0087	-	Nausea, vomiting, diarrhea, generalized burning erythema, mental confusion.	GI tract, CNS	NA	Nausea and vomiting can be expected to occur at a concentration of 0.05 mg/L. The most severe effects, including gastrointestinal problems, diarrhea, generalized burning erythema, and mental confusion, occur at a concentration of 0.78 mg/L.
TCDD (2,3,7,8-) 1746-01-6	1E-06	1E-07	5E-07	5E-08	Headache, nausea, vomiting, severe muscle pain, liver damage, chloracne, porphyria cutanea tarda, hair loss,	Liver, skin, kidneys, blood, REPR system	NA	Human lethal doses have been estimated to be greater than 100 ?g/kg (1.4 mg/L).

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
					hyperpigmentation, polyneuropathy, neurobehavioral effects, possible immunosuppression, thymic atrophy.			B carcinogen.
Tebuthiuron 34014-18-1	3.5	3.5	1	1	Reversible pancreatic changes.	Pancreas	NA	
Terbacil 5902-51-2	0.35	0.35	0.1	0.1	Pallor, prostration, vomiting, and rapid respiration.	Liver	NA	
Terbufos 13071-79-9	0.007	0.007	0.002	0.002	Nausea, vomiting, abdominal cramps, diarrhea, excessive salivation, headache, dizziness, weakness, excessive tearing and salivation, ocular pain, blurred vision, constricted pupils, incoordination, slurred speech, muscle twitches, mental confusion, drowsiness, difficulty breathing, cyanosis, cardiac irregularities, incontinence, convulsions, and coma.	CNS, CVS, ChE Inh	NA	
Tetrachloroethane (1,1,1,2-) 630-20-6	3	3	1	1	Weakness, fatigue, nausea, headache, incoordination; liver injury, decreased red blood cell counts, increased percent of large mononuclear cells in blood.	CNS, liver blood	NA	C carcinogen.
Tetrachloroethylene 127-18-4	2.8	2.8	0.9	0.9	Nausea, dizziness, incoordination, headache, sleepiness, liver damage.	Liver, CNS	NA	
Thallium 7440-28-0	0.01	0.01	0.003	0.003	Metallic taste in the mouth, fatigue, anxiety, irritability, gastroenteritis, diarrhea or constipation, vomiting, abdominal	Eyes, CNS, PNS, GI tract, lungs, liver, kidneys	NA	An oral dose of 3.4 mg/kg (48 mg/L) produced chest pain, vomiting, paresthesia of the hands

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
					pain, chest pain, paresthesia of the hands and feet, tremor, convulsions, pain and loss of muscle strength in the limbs, hair loss, vision loss; damage to the lungs, kidneys, and nervous system; hypertension, EKG changes and other cardiovascular effects.			and feet, and weakness; 7 mg/kg (100 mg/L) may be fatal. Symptoms of acute exposure are typically delayed hours to days.
Toluene 108-88-3	30	3	10	1	Fatigue, nausea, weakness, confusion; higher concentrations can cause headache, vomiting, diarrhea, depressed respiration, loss of muscle coordination.	CNS	Odor: 0.04 – 1 mg/L	CHID under development.
2,4,5-TP 93-72-1	0.3	0.3	0.09	0.09	Fatigue, weakness, nausea, vomiting, abdominal pain, diarrhea, muscle twitching, weakened reflexes, constricted pupils; high concentrations can produce profuse sweating, hypotension, painful neuritis, metabolic acidosis, fever, rapid heart beat, hyperventilation, and coma.	Liver, kidneys, CNS	NA	
Trichloroacetic acid 76-03-9	5.6	5.6	1.9	1.9	Gastrointestinal disturbances, acidosis, vomiting, diarrhea, and lassitude; decreased plasma lactate and glucose levels, and hypotension; high concentrations may cause CNS depression.	GI tract, liver, kidneys	NA	C carcinogen.
Trichloroacetonitrile 545-06-2	0.07	0.07	0.023	0.023			NA	

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Trichlorobenzene (1,2,4-) 120-82-1	0.2	0.2	0.06	0.06	Lethargy, incoordination, changes in liver, kidneys and adrenal glands.	Liver, kidneys, adrenal glands	NA	
Trichlorobenzene (1,3,5-) 108-70-3	0.8	0.8	0.3	0.3	Lethargy, incoordination, changes in liver, kidneys, and adrenal glands.	Liver, kidneys, adrenal glands	NA	
Trichloroethane (1,1,1-) 71-55-6	140	60	50	20	Headache, weakness, dizziness, increased reaction time, impaired judgment; high concentrations can cause severe vomiting and diarrhea, cardiac arrhythmias and liver damage.	CNS, CVS, liver	NA	Exposure to about 600 mg/kg (8.4 g/L) can cause incapacitating vomiting and diarrhea.
Trichloroethane (1,1,2-) 79-00-5	0.8	0.5	0.3	0.2	Headache, weakness, dizziness, nausea, vomiting, and diarrhea; drowsiness, loss of coordination and judgment; possible liver and kidney damage.	CNS, liver, kidneys	NA	C carcinogen.
Trichloroethylene 79-01-6	2.8	2.8	0.9	0.9	Headache, dizziness, blurred vision, fatigue, giddiness, tremor, sleepiness, nausea, vomiting, abdominal pain, cardiac arrhythmias, mild liver dysfunction; may cause birth defects.	CNS, CVS, liver, kidneys, REPR	NA	Doses of 21 to 35 g (4.2 - 7 G/L) can cause vomiting and abdominal pain followed by transient unconsciousness. probable human carcinogen. MEGs were derived from the ATSDR acute oral MRLs.
Trichloropropane (1,2,3-) 96-18-4	0.8	0.8	0.3	0.3	CNS damage, liver and kidney changes, lethargy, cardiovascular abnormalities.	CNS, liver, kidney, CVS, blood	NA	B carcinogen.
Trifluralin 1582-09-8	0.1	0.1	0.04	0.04	Liver and kidney changes, anemia, CNS depression.	CNS, liver, kidney, blood	NA	C carcinogen.

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Trinitroglycerol 55-63-0	0.007	0.007	0.002	0.002	Severe throbbing headache, nausea, hypotension, light-headedness; high exposure can cause flushing of the face and neck, vomiting, dizziness, delirium, confusion, methemoglobinemia, hallucinations, and difficulty breathing.	CVS, blood, CNS, testes	NA	Doses of 0.15 to 0.6 mg (0.03-0.12 mg/L) affect the cardiovascular system causing vasodilation and general relaxation of the smooth musculature.
Trinitrotoluene (2,4,6-) 118-96-7	0.025	0.025	0.008	0.008	Red pigmentation in the urine, abdominal pain, methemoglobinemia, anemia, ataxia, cyanosis, tremors; high concentrations may cause convulsions; liver damage, gastrointestinal tract irritation; male reproductive effects.	Liver, blood, GI tract, CNS	NA	C carcinogen.
Vinyl chloride 75-01-4	3.6	3.6	1.2	1.2	Headache, dizziness, loss of muscle coordination, inebriation, euphoria, fatigue, numbness and tingling of the extremities, drowsiness, and visual disturbances.	CNS	NA	A carcinogen.
VX 50782-69-9 ***TB MED 577**	0.015	-	0.005	-	Nausea, vomiting, diarrhea, abdominal cramps, headache, giddiness, dizziness, excessive salivation, tearing, miosis, blurred or dim vision, miosis, difficulty breathing, cardiac arrhythmias, loss of muscle coordination, muscle twitching, random jerking movements, convulsions, coma.	CNS, ChE Inh	NA	Single oral doses of 0.002 to 0.0045 mg/kg (0.028-0.063 mg/L) caused gastrointestinal effects in 5/32 volunteers; repeated doses of 0.00143 mg/kg/day (0.02 mg/L/day) in the drinking water 4 times/day for 7 days

Chemical CAS No.	5 L/day MEG † (mg/L) 5-day	 2-week	15 L/day MEG † (mg/L) 5-day	 2-week	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
								caused no effects. The human oral LD_{50} value has been estimated to be 0.0075 mg/kg (0.11 mg/L).
Xylenes 1330-20-7	60	60	20	20	Headache, weakness, dizziness, confusion, nausea, vomiting, abdominal pain, shivering, incoordination, loss of appetite, tremors, disturbed vision, salivation, and difficulty breathing; liver and kidney damage, and cardiac arrhythmias are possible.	CNS, liver, kidneys, blood, GI tract	Odor: 0.3 – 1.0 mg/L	The lowest oral lethal dose was reported to be 50 mg/kg (700 mg/L).
Zinc chloride [measured as Zinc] 7646-85-7	8	8	3	3	Severe stomach irritation, nausea, vomiting, and diarrhea.	GI tract	NA	

Footnotes on next page.

FOOTNOTES FOR TABLE D-1 – SHORT-TERM WATER-MEG VALUES

† In temperate conditions, the estimated rate of consumption is 5 liters/day. In arid regions, the estimated rate of consumption is 15 liters/day.

‡ The sources for odor and taste thresholds in water were the U.S. Environmental Protection Agency *Health Advisory* for individual chemicals and the National Library of Medicine's Hazardous Substance Database (HSDB).

§ The notes column shows estimated oral doses that can cause the toxic effects indicated when available. The reported doses were converted into mg/L concentrations in water (shown in parentheses) for 5 L/day consumption rates. Divide by 3 to convert to 15 L/day consumption rates. Estimated lethal doses and approximate toxic effect levels were obtained from the TOMES database software system, from Gosselin et al. (1976), from Hayes, *Pesticides Studied in Man* and from the EPA Health Advisory Source documents.

***TB MED 577** -- These values were taken from *TB MED 577, they are STANDARDS and should not be exceeded.
*Department of the Army (Da). *Sanitary Control And Surveillance Of Field Water Supplies*, Final Draft Technical Bulletin, Medical (TBMED) 577, May 1999.

Other values obtained from following hierarchy sources [USEPA HA-ADJ ≥ ATSDR MRL-ADJ> USEPA RFD–ADJ] unless otherwise noted (see RD 230 for more details):

ATSDR primary sources :
- Agency for Toxic Substances and Disease Registry (ATSDR), 1996. *Toxicological Profiles*. Prepared by Clement International Corporation under Contract No. 205-88-0608. Prepared for U.S. Department of Health and Human Services, Public Health Service, Washington, D.C.

US EPA primary sources:
-U.S. Environmental Protection Agency (USEPA), 1996a. 822-R-96-001, *Drinking Water Regulations and Health Advisories*, Office of Water, United States Environmental Protection Agency, October 1996.U.S. Environmental Protection Agency (USEPA), 1996b. Soil Screening Guidance: User's Guide. Office of Solid Waste and Emergency Response. Washington D.C

-U.S. Environmental Protection Agency (USEPA), 1999a. *Integrated Risk Information System (IRIS)*. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Cincinnati, OH.

CHID – Chemical Hazard Information for Deployments. Summarized information in fact sheet format is under development for notated chemicals.
EEG – electrocardiogram
NA – Not Available

Target organ/systems, carcinogenicity, and units information next page……

TABLE 2-4-1. TARGET ORGANS

TARGET ORGANS	
Eyes	Brain
Skin	Heart
Blood	Pancreas
Bladder	Adrenal Glands
Thyroid	Lungs
Bone	Liver
Fetus	Kidneys
Spleen	

TABLE 2-4-2. TARGET SYSTEMS

TARGET SYSTEMS	
CNS – Central Nervous System	CVS – Cardiovascular System
PNS – Peripheral Nervous System	ChE Inh – Cholinesterase Inhibitor
GI tract – Gastrointestinal Tract	UT – Urogenital Tract
RS – Respiratory System	CRC – Circulatory System
LRS – Lower Respiratory System	IMM – Immune System
URS – Upper Respiratory System	REPR – Reproductive System
ENDO – Endocrine System	HEM – Hemopoietic System
LYMP – Lymphatic System	

Units used:

g – gram
mg = milligram
L = Liter
mL = milliliter
mg/kg/day == milligram chemical per kilogram body weight (ingested) per day

µg/kg = micrograms per kilogram = ppb = parts per billion
mg/L = milligram per liter = ppm = part per million

Cancer Class Categories:

The scheme used by the USEPA for categorizing chemicals according to their carcinogenic potential is as follows (see Section 2.4.3):
Group A: Human carcinogen
Group B: Probable human carcinogen:
Group B1 - Limited evidence in epidemiological studies
Group B2 - Sufficient evidence from animal studies
Group C: Possible human carcinogen
Group D: Not classifiable
Group E: No evidence of carcinogenicity

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TABLE D-2. LONG-TERM, WATER MILITARY EXPOSURE GUIDELINES (1 YEAR DEPLOYMENT)

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Acenaphthene 83-32-9	8.4	2.8	NA	May cause slight changes in the liver.	Liver	NA	This chemical is a PAH. MEGs are derived using a relative potency (toxicity equivalency factor for carcinogencity as well as a relative comparison to Total Petroleum Hydrocarbon (TPH) toxicity estimates. Se section 3.3.5.10 in RD230)
Acenaphthylene 208-96-8	4.2	1.4	D	As with other polycyclic aromatic hydrocarbons (PAHs), toxicity following short-term exposure is minimal. Long-term exposure to PAHs can produce a variety of non-cancer effects including irritation of the eyes and photosensitivity, mild liver or kidney damage, anemia and other changes in the blood cells.	Liver, kidneys, blood, IMM	NA	See above (Acenaphthene)
Acetone 67-46-1	14	4.7	D	Headache, dizziness, CNS depression.	CNS	Odor: 20 mg/L	
Alachlor 15972-60-8	0.14	0.05	B2	May damage the liver, kidney and spleen; cancer.	Liver, kidneys, spleen	NA	
Aldrin 309-00-2	0.0004	0.00013	B2	Nausea, vomiting, diarrhea, hyperexcitability, tremors, limb jerks, convulsions, and ventricular fibrillation; reversible kidney and liver injury; cancer.	CNS, liver, kidneys	Odor: 0.017 mg/L	Ingestion of 25.6 mg/kg (360 mg/L) can produce convulsions; a single oral dose of 5 g (1 g/L is lethal.

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Anthracene 120-12-7	140	47	D	Contact may make the skin more susceptible to the effects of sunlight. Long-term exposure to PAHs can produce a variety of non-cancer effects including irritation of the eyes and photosensitivity, mild liver or kidney damage, anemia and other changes in the blood cells.	Liver, kidneys, blood, IMM, skin	NA	This chemical is a PAH. MEGs are derived using a relative potency (toxicity equivalency factor for carcinogencity as well as a relative comparison to Total Petroleum Hydrocarbon (TPH) toxity estimates. Se section 3.3.5.10 in RD230)
Aroclor-1016 12674-11-2	0.001	0.0003	NA	Nausea, vomiting, liver damage, facial edema, abdominal pain, weight loss, diarrhea; headache, dizziness, depression, weakness, transient visual disturbances; chloracne; birth defects, peripheral nerve damage. Cumulative toxicity; liver and kidney damage.	CNS, liver, kidneys	NA	Minimal oral dose expected to cause symptoms is 500 mg (7 mg/kg).
Aroclor-1254 11097-69-1	0.0007	0.0002	NA	Nausea, vomiting, liver damage, facial edema, abdominal pain, weight loss, diarrhea; headache, dizziness, depression, weakness, transient visual disturbances; chloracne; birth defects, peripheral nerve damage. Cumulative toxicity, liver and kidney damage.	CNS, liver, kidneys	NA	Minimal oral dose expected to cause symptoms is 500 mg (7 mg/kg).

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Arsenic 7440-38-1 ***TB MED 577**	0.06	0.02	A	Facial swelling, vomiting, loss of appetite, abdominal pain; diarrhea, shock, muscle cramps, headache, chill, cardiac abnormalities, decreased white blood cell count, and enlargement of liver; delayed effects include sensory and motor peripheral polyneuropathies. Hyperpigmentation of the skin (especially on the palms of the hands and soles of the feet), anemia, weakness, incoordination, mental confusion, cirrhosis of the liver, hair loss, and nail changes; cancer.	Liver, kidneys, blood, CNS, GI tract, IMM	NA	The risk of developing symptoms of acute toxicity increases as the concentration in drinking water increases above 0.3 mg/L. The risk of severe toxic effects and fatalities increases as concentrations rise above 14 mg/L. CHID under development.
Benzene 71-43-2	0.042	0.014	A	Vomiting, loss of coordination, light-headedness, headache, anemia, shallow/rapid pulse, loss of concentration, delirium, chemical pneumonitis, dizziness, pallor, flushing, weakness, and breathlessness; high concentrations may cause convulsions, coma, or irregular heart beat. Fatigue, headache, dizziness, nausea, loss of appetite, weakness, nosebleeds, pallor, and bleeding gums; bone marrow damage; immunosuppression;	Eyes, skin, RS, blood, CNS, IMM	Odor: 2.0 mg/L Taste: 0.5 – 4.5 mg/L	The LD_{LO} has been estimated to equal 50 mg/kg. CHID under development.

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Benzo(a)anthracene 56-55-3	0.14	0.05	B2	As with other PAHs, toxicity following short-term exposure is minimal. Long-term exposure to PAHs can produce a variety of non-cancer effects including irritation of the eyes and photosensitivity, mild liver or kidney damage, anemia and other changes in the blood cells. Long-term exposure may cause cancer.	Liver, kidneys, blood, IMM	NA	This chemical is a PAH. MEGs are derived using a relative potency (toxicity equivalency factor for carcinogencity as well as a relative comparison to Total Petroleum Hydrocarbon (TPH) toxity estimates. Se section 3.3.5.10 in RD230)
Benzo(a)pyrene 50-32-8	0.014	0.005	B2	Toxicity from short-term exposure is low. Long-term exposure may cause depression of the immune system; mild liver or kidney damage; changes in the blood composition such as aplastic anemia and pancytopenia; and cancer. Effects on the developing fetus have been observed in laboratory animals.	Liver, kidneys, blood, IMM	NA	See above (Benzo(a)anthracene)
Benzo(b)fluoranthene 205-99-2	0.14	0.05	B2	As with other polycyclic aromatic hydrocarbons (PAHs), toxicity following short-term exposure is minimal. Long-term exposure to PAHs can produce a variety of non-cancer effects including irritation of the eyes and photosensitivity, mild liver or kidney damage, anemia and other changes in the blood cells. Long-term exposure may cause cancer.	Liver, kidneys, blood, IMM	NA	See above (Benzo(a)anthracene)

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Benzo(k)fluoranthene 207-0809	1.4	0.5	B2	Toxicity following short-term exposures is minimal.. Long-term exposure to PAHs can produce a variety of non-cancer effects including irritation of the eyes and photosensitivity, mild liver or kidney damage, anemia and other changes in the blood cells. Long-term exposure may cause cancer.	Liver, kidneys, blood, IMM	NA	See above (Benzo(a)anthracene)
Beryllium 7440-41-7	0.02	0.007	B2	Low acute toxicity by ingestion. Rickets (fragile or weakened bones); cancer.	Bone	NA	
Bis(2-ethylhexyl)-phthalate 117-81-7	0.28	0.056	B2	Liver damage, possible teratogenic and carcinogenic effects.	Skin, liver, REPR, CNS, GI tract	NA	Chronic exposure may cause liver tumors.
Boron 7440-42-8	1.7	0.4	D	Vomiting, abdominal pain, diarrhea; headache, tremors, restlessness, weakness, convulsions; may affect the liver, and may cause skin rash and desquamation.	CNS, skin, kidneys	NA	Prolonged ingestion/skin absorption may result in anorexia, weight loss, anemia. Long term USEPA and State standards range 0.6 – 1.0 mg/L
Bromodichloromethane 74-97-5	0.3	0.1	B	Loss of appetite, nausea, vomiting, abdominal pain, severe headache, confusion, dizziness, memory impairment, weakness, tremors and convulsions; elevated carboxyhemoglobin; kidney, liver tumors in animals.	CNS, skin, kidneys	NA	Long term USEPA and State standards range 0.6 – 1.0 mg/L
sec-Butylbenzene 135-98-8	0.15	0.05	NA	Skin irritation, CNS depression, incoordination, nausea, general anesthetic effects.	Skin, CNS	NA	

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Cadmium 7440-43-9	0.007	0.002	NA	Nausea, vomiting, diarrhea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock, and renal failure. Pain resulting from softening or decalcification of the bones, osteoporosis, irreversible kidney disease, anemia.	Kidneys, liver	NA	Ingestion of 3 mg (0.6 mg/L) may cause vomiting; 30 mg (6 mg/L) of soluble cadmium salts can produce severe toxic symptoms; 350 mg (70 mg/L) may be fatal.
Carbon disulfide 75-15-0	0.14	0.05	NA	Dizziness, headache, nausea, vomiting, diarrhea, fatigue, palpitations and weakness; high concentrations may cause psychosis, tremor, delirium, coma, muscle spasm, convulsions, difficulty breathing, and liver damage. Decreased fertility in males and females.	CNS, PNS, liver, REPR s	NA	
Chlordane 57-74-9	0.008	0.003	B2	Nausea, vomiting, diarrhea, headache, excitability, confusion, weakness, incoordination; high concentrations may cause delirium, muscle spasms, convulsions or seizures, coma, pulmonary edema, and difficulty breathing. Kidney and liver degeneration; blood dyscrasias; cancer.	CNS, liver, kidneys	NA	Ingestion of 28 to 56 mg/kg (390-780 mg/L) may cause severe effects such as convulsions. The fatal human dose lies between 6 and 60 g (1 and 10 g/L). The onset of symptoms occurs 45 minutes to several hours after ingestion.

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Chloride 16887-00-6 ***TB MED 577**	600	600	NA	Reduced water consumption due to high chloride concentrations can lead to dehydration, with symptoms including weariness, apathy, impaired coordination, delirium, heat stroke.	None (palatability issue; see notes)	NA	Exposure guidelines are based on palatability; at 600 mg//L, 2% of the military population might refuse to drink water and may suffer dehydration; at 1,000 mg/L, 10% would be at risk of dehydration.
Chloroform 67-66-3	1.4	0.5	B2	Dizziness, mental dullness, headache, nausea, confusion, fatigue, narcosis, liver and kidney damage/cancer; renal necrosis.	Kidneys, CNS, bladder, fetus	NA	USEPA long-term standard (MCL) = 0.1 mg/L States range 0.6 – 0.005 mg/L.
Chloromethane (Methyl chloride) 74-87-3	0.5	0.17	C	Headache, drowsiness, giddiness, dizziness, confusion, incoordination, vomiting, abdominal pain, diarrhea, breathing difficulties; high concentrations may cause unconsciousness, convulsions, coma, visual disturbances, and may damage the kidneys, liver, or blood; cancer.	CNS, liver, kidneys, REPR	NA	Symptoms of chloromethane exposure may be delayed in onset.
Chlorothalonil 1897-45-6	0.2	0.07	B2	Vomiting, rapid breathing, GI irritation, weakness, and sedation. Cumulative toxicity; incoordination, rapid breathing, hematuria (blood in the urine), nosebleed, delayed hypersensitivity; cancer.	CNS, GI tract, UT	NA	
Chromium (total) 7440-47-3	0.3	0.1	D	The toxicity of chromium has been attributed primarily to hexavalent chromium compounds.	Kidneys, liver	NA	The MEGs for total chromium were based on studies with hexavalent chromium [Cr(VI)] and reflect the toxicity of Cr(VI) compounds.

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Chromium III 16065-83-1	21	7	NA	Hexavalent chromium compounds are more toxic than trivalent chromium compounds.	Kidneys, liver	NA	
Chromium VI 18540-29-9	0.3	0.1	NA	Ingestion of hexavalent chromium compounds may cause GI irritation, epigastric pain, nausea, vomiting, diarrhea, liver and kidney damage, internal bleeding, circulatory collapse, unconsciousness, and death. Reduced fertility and birth defects are possible.	Kidneys, liver	NA	Doses of 0.5 – 1.5 g (7-21 mg/kg) $K_2Cr_2O_7$ have been fatal.
Chrysene 218-01-9	4.2	1.4	B2	As with other PAHs, toxicity following short-term exposure is minimal. Long-term exposure to PAHs can produce a variety of non-cancer effects including irritation of the eyes and photosensitivity, mild liver or kidney damage, anemia and other changes in the blood cells, and immunosuppression. Long-term exposure may cause cancer.	Liver, kidneys, blood, IMM	NA	This chemical is a PAH. MEGs are derived using a relative potency (toxicity equivalency factor for carcinogencity as well as a relative comparison to Total Petroleum Hydrocarbon (TPH) toxicity estimates. Se section 3.3.5.10 in RD230)
Copper (II) (Salts, Oxide) 1317-38-0	1.0	1.0	D	Ingestion at high concentrations can produce vomiting, diarrhea, nausea, abdominal pain and a metallic taste in the mouth. Potential kidney and liver injury after chronic exposures.	GI tract, liver, kidneys	NA	The major soluble salts e.g., copper (II) sulfate, copper II chloride) are of most toxic concern. Elemental copper (7440-50-8) is an essential element and therefore *deficiencies* can result in adverse health effects. USEPA and States standards range 1.0 – 1.3 mg/L

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Cumene 98-82-8	1.4	0.47	D	CNS effects, skin irritation.	CNS, Skin	NA	
Cyanide 57-12-5 ***TB MED 577**	6	2	NA	Headache, breathlessness, weakness, palpitation, nausea, vomiting, giddiness, tremor, rapid heart beat, dizziness, confusion, anxiety, agitation, confusion, cardiac arrhythmias, seizures, stupor, and coma. CNS effects (insomnia, memory loss, tremors); degeneration of spinal cord and optic nerve; enlargement of the thyroid gland; reduced fertility and birth defects are possible.	CNS, RS, CVS, liver, kidneys	NA	Concentrations between 12 and 24 mg/L may cause changes in blood chemistry without clinical effects. Severe but reversible symptoms may occur at concentrations of 24 to 48 mg/L; concentrations higher than 48 mg/L cause life-threatening toxicity.
2,4-D (2,4-Dichlorophenoxy-acetic acid) 94-75-7	0.14	0.05	D	Nervous system damage, vomiting, diarrhea, lethargy, incoordination, weakness, paralysis, stupor, miosis, stiffness in the extremities, muscle spasms, lowered blood pressure, convulsions; transient liver and kidney damage; may cause birth defects and reduced fertility. Cumulative toxicity.	CNS, liver, kidneys	NA	Ingestion of a single dose of 5 mg/kg (70 mg/L) and repeated doses of 7 mg/kg/day (98 mg/L) for 21 days caused no effects. The single oral lethal dose has been estimated to be 355 mg/kg (5 g/L). Survival following a dose of about 110 mg/kg (1.5 g/L) has been reported.

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
p,p'-DDT 50-29-3	0.007	0.002	NA	Vomiting, tingling of lips, tongue, and face; malaise, headache, sore throat, fatigue, tremors; apprehension, ataxia, confusion, convulsions, coma and partial paralysis. Estrogenic effects; may reduce fertility.	Eyes, skin, CNS, kidneys, liver, PNS	NA	
Diazinon 333-41-5	0.007	0.002	E	Nausea, vomiting, diarrhea, headache, dizziness, weakness, excessive tearing and salivation, ocular pain, blurring/dimness of vision, miosis, loss of muscle coordination, slurred speech, muscle twitching, disorientation, drowsiness, difficulty breathing, hypertension, hypotension, cardiac arrhythmias, random jerky movements, incontinence, convulsions, and coma. Cumulative toxicity; loss of visual acuity.	Eyes, RS, CNS, CVS, blood, ChE Inh	NA	
Dibromochloromethane 594-18-3	2.8	0.9	C	CNS functional disturbances including sedation and anesthesia; reversible liver and kidney injury.	CNS, liver, kidneys	NA	USEPA and State standards range 0.8 – 0.0002 mg/L.
Dibromochloropropane 96-12-8	0.03	0.009	B2	GI distress; may damage the kidney, liver, and testes. Kidney and liver damage, atrophy of the testes and sterility in males; cancer.	Liver, kidneys, spleen, REPR, GI tract, CNS	Odor: 0.01 – 3.1 mg/L	

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Dieldrin 60-57-1	0.0007	0.0002	B2	Early signs of toxicity are headache, dizziness, nausea, vomiting, malaise, sweating, tremors, limb jerks, EEG changes, convulsions, and coma; secondary effects include hypertension, cardiac arrhythmias, and fever; sleep, memory, behavioral disturbances, headache, and convulsions may persist for months following exposure. Cumulative toxicity; fainting, muscle spasms, tremors, weight loss, reduced psychomotor skills, hemolytic anemia; reproductive effects may occur; cancer	CNS	Odor 0.04 mg/L	No effects were seen in volunteers given doses of 0.21 mg (0.04 mg/L). Serious effects may occur at a dose of 10 mg/kg (140 mg/L); 29 mg/kg (420 mg/L) caused profuse vomiting or prolonged convulsions; the acute mean lethal dose for humans has been estimated to lie between 230 and 70 mg/kg (280 to 980 g/L). Oral doses of dieldrin ranging from 10 to 211 ?g over a period of 10 months had no adverse effects in volunteers.
Dinitrobenzene (1,3-) 99-65-0	0.06	0.02	D	Methemoglobinemia associated with headache, irritability, dizziness, weakness, nausea, lethargy, shortness of breath, liver damage. May cause reduced fertility and birth defects.	Blood, liver, CNS, CVS	NA	The lethal dose has been estimated to lie between 5 and 50 mg/kg (70 and 700 mg/L).
Dinoseb 88-58-7	0.014	0.005	D	Nausea, vomiting, abdominal pain, marked thirst, fatigue, sweating, facial flushing, rapid heart beat, fever, weight loss, respiratory distress, cyanosis, restlessness, anxiety, muscle cramps, excitement, convulsions, and coma. Liver or kidney damage; cataracts; may affect fertility.	CNS, REPR	NA	

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Disulfoton 298-04-4	0.004	0.001	E	Headache, loss of appetite, nausea, vomiting, abdominal cramps, diarrhea, weakness, dizziness, confusion, slurred speech, salivation, tearing, profuse sweating, shortness of breath, tightness of the chest, changes in heart rate, cyanosis, miosis, blurred vision, runny nose, slow pulse, muscle twitching, tremors, muscle cramps, incoordination, convulsions, coma, and shock. Decreased visual acuity, liver injury, altered tendon reflexes.	Eyes, RS, CNS, CVS, ChE Inh	NA	Oral doses of 0.75 mg/d (0.15 mg/L) for 30 days produced no significant effects in volunteers. The human LD_{50} has been estimated to be 5 mg/kg (70 mg/L).
Endrin 72-20-8	0.006	0.002	D	Headache, dizziness, nausea, vomiting, hypersalivation, insomnia, lethargy, weakness, agitation and confusion; high concentrations may cause convulsions, stupor, tremors, and coma; headache, dizziness, sleepiness, weakness, and loss of appetite may persist for 2 to 4 weeks.	CNS	NA	Convulsions may be induced in humans by doses of 0.2 to 0.25 mg/kg (2.8 to 3.5 mg/L); a dose of 1 mg/kg (14 mg/L) can induce repeated seizures.
Ethyl benzene 100-41-4	1.4	0.5	D	Headache, nausea, weakness, dizziness, sleepiness, fatigue, loss of coordination, and coma.	CNS	Odor: 0.062 mg/L Taste: 0.025 mg/L	This chemical is a PAH. MEGs are derived using a relative potency (toxicity equivalency factor for carcinogencity as well as a relative comparison to Total Petroleum Hydrocarbon (TPH) toxicity estimates. Se section 3.3.5.10 in RD230)
Ethylene dibromide 106-93-4	0.0012	0.0004	B2	Liver and kidney damage, vomiting, excitement and other CNS effects; may affect fertility in males; cancer.	CNS, liver, kidneys, REPR	NA	A single oral dose of 65 mg/kg (900 mg/L) may be lethal.

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Fenamiphos 22224-92-6	0.007	0.002	D	Nausea, vomiting, abdominal cramps, diarrhea, salivation, headache, dizziness, weakness, runny nose, blurred vision, constricted pupils, incoordination, slurred speech muscle twitches, random jerky movements, mental confusion, disorientation, drowsiness, difficulty breathing, cardiac irregularities, incontinence, convulsions, and coma. Cumulative toxicity.	CNS, CVS, ChE Inh	NA	
Fluoranthene 206-44-0	5.6	1.9	D	Fluoranthene can irritate the eyes. Contact may make the skin more susceptible to the effects of sunlight. Long-term exposure to PAHs can produce a variety of non-cancer effects including irritation of the eyes and photosensitivity, mild liver or kidney damage, anemia and other changes in the blood cells, and immunosuppression	Liver, kidneys, blood, IMM	NA	(This chemical is a PAH. MEGs are derived using a relative potency (toxicity equivalency factor for carcinogencity as well as a relative comparison to Total Petroleum Hydrocarbon (TPH) toxicity estimates. Se section 3.3.5.10 in RD230)
Fluorene 86-73-7	5.6	1.9	D	Skin or eye irritation.	Skin, eyes	NA	See above (Fluoranthene)

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Fonofos 944-22-9	0.03	0.01	D	Loss of appetite, nausea, vomiting, abdominal cramps, diarrhea, headache, dizziness, weakness, confusion, blurred vision, constricted pupils, slurred speech, profuse sweating, salivation, and runny nose; cardiac irregularities, difficulty breathing, muscle twitching, paralysis, convulsions, coma, or respiratory arrest may occur. Nervous behavior, tremors, liver damage, GI effects, increased nasal, salivary and lacrimal secretions.	CNS, CVS, ChE Inh	NA	
Heptachlor 76-44-8	0.007	0.002	B2	Nausea, vomiting, diarrhea, kidney and liver damage; hyperexcitability, tremors, convulsions, and paralysis. Cumulative toxicity; blood dyscrasias. Reduced fertility has been observed in animal studies; cancer.	CNS, liver	NA	A dose of 1 to 3 g (200-600 mg/L) has been estimated to cause serious symptoms in humans, especially liver impairment.
Heptachlor epoxide 1024-57-3	0.0002	0.00006	B2	Apprehension, agitation, muscle twitching and spasms, tremor, incoordination, vomiting, GI upset, abdominal pain; convulsions; kidney injury and liver damage; cancer.	CNS, liver	NA	
Hexachlorobenzene 118-74-1	0.004	0.0013	B2	Headache, nausea, cyanosis, muscle spasm, convulsions, liver injury, birth defects. Porphyria cutanea tarda, enlargement of the thyroid and lymph nodes, reduced bone density, skin photosensitization, liver, kidney, and lung damage.	CNS, blood, liver, kidneys	NA	

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Lead compounds No specified CAS. (measured as Total Lead)	0.015	0.015	--	Anxiety, irritability, insomnia, lack of appetite, anemia, headache, muscle weakness, restlessness, reproductive effects in developing fetus are pronounced. Possible kidney and reproductive effects after longer chronic exposures.	CNS, fetus	NA	Primary health impacts are to children/ developing fetus. But high concentrations and/or long exposures can result in health impacts to adults. MEGs were selected from general information for lead ions and compounds, including statements in the literature referenced to lead compounds, lead salts, etc. Some lead compounds (e.g. Tetra ethyl lead) have there own unique – and potent – toxicity. This MEG should be used when assessing Total Lead analytical results. CHID under development.
Lindane 58-89-9 ***TB MED 577**	0.6	0.2	C	Irritability, restlessness, insomnia, anxiety, dizziness, malaise, headache, nausea, fever, cyanosis, vomiting, and loss of muscle coordination; higher exposure can cause muscle spasms, seizures, and convulsions. Liver and kidney damage; may affect fertility; cancer.	CNS, REPR	NA	Increasing susceptibility to nervous system changes may occur at concentrations between 0.6 and 3.5 mg/L. Signs of poisoning begin to develop at 3.5 mg/L. The mean lethal dose is approximately 400 mg/kg (5.6 g/L).

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Magnesium 7439-95-4 ***TB MED 577**	100	30	NA	Laxative effects that can lead to dehydration, with symptoms of discomfort, weariness, apathy, impaired coordination, delirium, and heat stroke.	GI tract	NA	Laxative effects occur at doses greater than 480 mg (96 mg/L).
Malathion 121-75-5	0.3	0.1	D	Miosis, blurred vision, tearing, increased salivation, weakness, nausea, vomiting, abdominal cramps, diarrhea, giddiness, confusion, loss of muscle coordination, runny nose, headache, chest tightness, difficulty breathing, pulmonary edema, muscle twitching, coma, respiratory distress, cardiac irregularities, and convulsions. Chronic exposure can cause fatigue, visual disturbances, headache, nausea, abdominal pain, and twitching; kidney and liver damage; may affect fertility.	Lungs, liver, CNS, CVS, ChE Inh	NA	No effects were seen in volunteers after a single oral dose of 0.84 mg/kg (11.6 mg/L) or repeated doses of 16 mg/day (3.2 mg/L) for 47 days. The fatal dose is believed to be between 350 – 1000 mg/kg (4.9 – 14 mg/L).
Mercury (inorganic) 7439-97-6	0.002	0.0007	D	Tremors, peripheral neuropathy, fatigue, memory loss, personality changes, kidney damage, cough, chest pain, difficulty breathing, liver damage, diarrhea, nausea, vomiting. Reduced visual acuity, tremor, ataxia, nerve fiber degeneration, loss of taste, smell, change in motor function, loss of higher mental function, irritability, headache, fatigue, weakness, loss of memory, depression, insomnia, apathy, hallucinations, seizures, mania; birth defects, kidney damage, dementia.	CNS	NA	

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Mercury (Methyl) 22967-92-6	0.0042	0.0014	NA	Paresthesia, impaired hearing, taste and small; slurred speech, unsteady gait, muscle weakness, irritability, memory loss, depression, insomnia, ataxia, loss of visual acuity, tremors, confusion, hallucinations, excitement, loss of consciousness; nerve degeneration. Reproductive effects are possible.	CNS, kidneys	NA	Single oral doses of 10-60 mg/kg have been fatal.
Methyl ethyl ketone 78-93-3	8.4	2.8	D	Headache, dizziness, vomiting.	CNS, Skin	Taste: 0.05 mg/L	
Methyl parathion 298-00-0	0.04	0.013	D	Nausea, vomiting, abdominal cramps, diarrhea, salivation, headache, weakness, giddiness, dizziness, runny nose, blurred vision, miosis, cardiac arrhythmias and ischemia, difficulty breathing; muscle twitch, convulsions, liver and kidney damage, coma and respiratory paralysis are possible at high concentrations. Cumulative toxicity.	Eyes, CNS, CVS, liver, kidneys, ChE Inh	NA	Volunteers receiving oral doses of 22 mg/day (4.4 mg/L) suffered no ill effects. Depression of red blood cell cholinesterase occurred at doses of 30 mg/day (6 mg/L) which was considered to be the level of minimal toxicity. Ingestion of 50 to 200g (10-40 g/L) has resulted in death; the minimum adult lethal dose by the oral route may be less than 1.84 gm (370 mg/L).
Molybdenum 7439-98-7	0.07	0.02	NA	Weight loss, diarrhea, poor muscle coordination, headaches, muscle or joint aching. Changes in liver function, gout, anemia.	Liver, kidneys, blood	NA	

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Naphthalene 91-20-3	0.5	1.7	D	Headache, profuse perspiration, confusion, listlessness, lethargy, muscle twitching, coma; nausea, vomiting, abdominal cramps, diarrhea; hemolytic anemia, methemoglobinemia; cataracts, liver and kidney damage.	Eyes, blood , liver, kidneys, CNS	NA	This chemical is a PAH. MEGs are derived using a relative potency (toxicity equivalency factor for carcinogencity as well as a relative comparison to Total Petroleum Hydrocarbon (TPH) toxicity estimates. Se section 3.3.5.10 in RD230)
Oxamyl (Vydate) 23135-22-0	0.35	0.1	E	Tremors, blurred or dim vision, increased salivation, tearing, incontinence, diarrhea, abdominal cramps, nausea, vomiting, and difficulty breathing; convulsions, coma, and respiratory paralysis are possible at high concentration; protected malaise and weakness may persist after apparent recovery.	ChE Inh	NA	
Paraquat 1910-42-5	0.06	0.02	E	Abdominal cramping, nausea, vomiting, bloody diarrhea, headache, difficulty swallowing, fever, decreased blood pressure; higher concentrations can cause heart, kidney and liver injury and extensive lung damage with difficulty breathing, pulmonary fibrosis and edema; may reduce fertility in males. Edema, interstitial bleeding; lung, kidney, and liver damage.	Lung, liver, kidneys, GI tract	NA	Single oral doses of 1 to 4 g (200 to 800 mg/L) have caused fatalities.

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Phenanthrene 85-01-8	4.2	1.4	D	Contact may make the skin more susceptible to the effects of sunlight (photosensitization). As with other polycyclic aromatic hydrocarbons (PAHs), toxicity following short-term exposure is low. Long-term exposure to PAHs can produce a variety of non-cancer effects including irritation of the eyes and photosensitivity, mild liver or kidney damage, anemia and other changes in the blood cells, and immunosuppression.	Liver, kidneys, blood, IMM, skin	NA	This chemical is a PAH. MEGs are derived using a relative potency (toxicity equivalency factor for carcinogencity as well as a relative comparison to Total Petroleum Hydrocarbon (TPH) toxicity estimates. Se section 3.3.5.10 in RD230)
n-Propylbenzene 103-65-1	0.15	0.05	D	Irritation of throat and skin, CNS depression, incoordination, nausea, general anesthetic effects.	CNS, Skin	NA	
Pyrene 129-00-0	4.2	1.4	D	Pyrene is irritating to exposed skin and eyes. Contact may make the skin more susceptible to the effects of sunlight. As with other polycyclic aromatic hydrocarbons (PAHs), toxicity following short-term exposure is low. Long-term exposure to PAHs can produce a variety of non-cancer effects including irritation of the eyes and photosensitivity, mild liver or kidney damage, anemia and other changes in the blood cells, and immunosuppression.	Liver, kidneys, blood, IMM, skin	NA	See Note for Phenanthrene
Simazine 122-34-9	0.07	0.02	C	Incoordination, tremor, weakness, muscle spasms, difficulty breathing; cancer	CNS, kidneys, liver	NA	

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Strontium 7440-24-6	8.4	2.8	NA	Skin irritation, altered heart function, bone abnormalities.	Bone, CVS, skin, eyes	NA	
Sulfate 14808-79-8 ***TB MED 577**	300	100	NA	Ingestion can cause laxative effects which can lead to dehydration, with symptoms of discomfort, weariness, apathy, impaired coordination, and delirium.	GI tract	NA	Laxative effects occur at doses greater than 1490 mg (300 mg/L).
Terbufos 13071-79-9	0.00035	0.00012	D	Nausea, vomiting, abdominal cramps, diarrhea, excessive salivation, headache, dizziness, weakness, excessive tearing and salivation, ocular pain, blurred vision, constricted pupils, incoordination, slurred speech, muscle twitches, mental confusion, drowsiness, difficulty breathing, cyanosis, cardiac irregularities, incontinence, convulsions, and coma. Cumulative toxicity is possible.	CNS, CVS, ChE Inh	NA	
Tetrachlorodibenzo-dioxin (2,3,7,8-) (TCDD) 1746-01-6	1.4E-08	4.7E-09	B2	Headache, nausea, vomiting, severe muscle pain, liver damage, chloracne, porphyria cutanea tarda, hair loss, hyperpigmentation, polyneuropathy, neurobehavioral effects, possible immunosuppression, thymic atrophy, liver damage. Cumulative toxicity; cancer.	Liver, skin, kidneys, blood, REPR	NA	Single oral lethal doses have been estimated to be greater than 100 ?g/kg (1.4 mg/L). The minimum cumulative toxic dose has been estimated to be 0.1 ?g/kg.
Toluene 108-88-3	3	1	D	Fatigue, nausea, weakness, confusion; higher concentrations can cause headache, vomiting, diarrhea, depressed respiration, loss of muscle coordination.	CNS	NA	CHID under development.
Toxaphene 8001-35-2	0.014	0.005	B2	Salivation, restlessness, hyperexcitability, tremors, spasms and convulsions. Liver and kidney degeneration; possible immune system suppression; cancer.	CNS	NA	The acute oral LD_{50} has been estimated to be 60 mg/kg.

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Trifluralin 1582-09-8	0.1	0.03	C	Liver and kidney changes, anemia, CNS depression. Occasional vomiting, kidney and liver damage; decreased white and red blood cell counts; cancer.	CNS, liver, kidneys, blood	NA	
Trimethylbenzene (1,2,4-) 95-63-6	0.7	0.23	NA	Irritation of skin, eyes, nose, throat, bronchitis, anemia, drowsiness, fatigue, nausea	Eyes, skin, respiratory system., CNS, blood	NA	
Trimethylbenzene (1,3,5-) 108-67-8	0.7	0.23	NA	Irritation of skin, eyes, nose, throat, bronchitis, anemia, drowsiness, fatigue, nausea	Eyes, skin, RS, CNS, blood	NA	
Vanadium 7440-62-2	0.1	0.03	NA	Vanadium salts can cause abdominal cramping, diarrhea, black stools, and green tongue; bone marrow depression leading to changes in numbers of white and red blood cells. High concentrations can cause tremors, headache, and tinnitus. Irregular or slow heartbeat, kidney damage.	Bone, kidneys, CNS	NA	Metallis vanadium has low oral toxicity. It is ubiquitous in soils and approximately 20 ?g are normally ingested daily. However, ingestion of 60-120 mg or a vanadium salt may be fatal. Pentavalent forms and vanadates are the most toxic. The effects shown in the table are primarily those of vanadium salts.
Xylene 1330-20-7	40	13	D	Headache, weakness, dizziness, confusion, nausea, vomiting, abdominal pain, shivering, incoordination, loss of appetite, tremors, disturbed vision, salivation, and difficulty breathing; liver and kidney damage, and cardiac arrhythmias are possible.	CNS, liver, kidneys, blood, GI tract	NA	

Chemical CAS No.	5 L/day † 1-yr MEG (mg/L)	15 L/day † 1-yr MEG (mg/L)	Cancer Group	Potential Symptoms	Target Organs and Systems	Odor, Taste Threshold ‡	Notes §
Zinc 7646-85-7	4	1.3	NA	Severe stomach irritation, nausea, vomiting, and diarrhea (for zinc chloride).	GI tract	NA	

Footnotes on next page.

FOOTNOTES FOR TABLE D-2 – LONG-TERM WATER-MEG VALUES

† In temperate conditions, the estimated rate of consumption is 5 L/day. In arid regions, the estimated rate of consumptions is 15 L/day.

‡ The sources for odor and taste thresholds in water were the USEPA, Health Advisory for individual chemicals and the National Library of Medicine's Hazardous Substance Database (HSDB).

§ This column shows oral doses that have been estimated to cause the indicated toxic effects. The reported doses were converted into concentrations in water (shown in parentheses) for 5 liters/day consumption rates. Divide by 3 to convert to 15 liters/day consumption rates. Estimated lethal doses and approximate toxic effect levels were obtained from the TOMES database software system, from Gosselin et al (1976), from Hayes, *Pesticides Studied in Man*, and from the EPA Health Advisory Source documents.

***TB MED 577** -- These values were taken from *TB MED 577, they are STANDARDS and should not be exceeded.
*Department of the Army (DA). *Sanitary Control And Surveillance Of Field Water Supplies*, Final Draft Technical Bulletin, Medical (TBMED) 577, May 1999.

Other values obtained from following hierarchy sources [USEPA HA-ADJ ≥ ATSDR MRL-ADJ> USEPA RFD–ADJ] unless otherwise noted (see RD 230 for more details):

US EPA primary sources:

-U.S. Environmental Protection Agency (USEPA), 1996a. 822-R-96-001, *Drinking Water Regulations and Health Advisories*, Office of Water, United States Environmental Protection Agency, October 1996.U.S. Environmental Protection Agency (USEPA), 1996b. Soil Screening Guidance: User's Guide. Office of Solid Waste and Emergency Response. Washington D.C

-U.S. Environmental Protection Agency (USEPA), 1999a. *Integrated Risk Information System (Iris)*. Environmental Criteria And Assessment Office, Office Of Health And Environmental Assessment, Cincinnati, Ohio

-U.S. Environmental Protection Agency (USEPA), 1997a. *Health Effects Summary Tables (Heast)*. 1997. USEPA 540/R-97-036, Pb97-921199. Office Of Research And Development, Office Of Emergency And Remedial Response, U.S Environmental Protection Agency, Washington D.C

ATSDR primary sources :

- Agency for Toxic Substances and Disease Registry (ATSDR), 1996. *Toxicological Profiles*. Prepared by Clement International Corporation under Contract No. 205-88-0608. Prepared for U.S. Department of Health and Human Services, Public Health Service, Washington, D.C.

CHID – Chemical Hazard Information for Deployments. Additional Fact Sheet information is under development for notated Chemicals..
BW – Body weight
EEG – electroencephalogram (brain waves)
LC_{Lo} – Lethal Concentration – low (estimate of small percentage (e.g. 1-5 %) exposed will succumb lethally
MRL – Minimum Risk Level
NA – Not Available;
PAH – Polycyclic Aromatic Hydrocarbon
UD- Under development

Target organ/systems, Carcinogenicity, and units information next page……

TABLE 2-4-1. TARGET ORGANS

TARGET ORGANS	
Eyes	Brain
Skin	Heart
Blood	Pancreas
Bladder	Adrenal Glands
Thyroid	Lungs
Bone	Liver
Fetus	Kidneys
Spleen	

TABLE 2-4-2. TARGET SYSTEMS

TARGET SYSTEMS	
CNS – Central Nervous System	CVS – Cardiovascular System
PNS – Peripheral Nervous System	ChE Inh – Cholinesterase Inhibitor
GI tract – Gastrointestinal Tract	UT – Urogenital Tract
RS – Respiratory System	CRC – Circulatory System
LRS – Lower Respiratory System	IMM – Immune System
URS – Upper Respiratory System	REPR – Reproductive System
ENDO – Endocrine System	HEM – Hemopoietic System
LYMP – Lymphatic System	

Units used:

g – gram
mg = milligram
L = Liter
mL = milliliter
mg/kg/day == milligram chemical per kilogram body weight (ingested) per day

µg/kg = micrograms per kilogram = ppb = parts per billion
mg/L = milligram per liter = ppm = part per million

Cancer Class Categories:

The scheme used by the USEPA for categorizing chemicals according to their carcinogenic potential is as follows (see Section 2.4.3):
Group A: Human carcinogen
Group B: Probable human carcinogen:
Group B1 - Limited evidence in epidemiological studies
Group B2 - Sufficient evidence from animal studies
Group C: Possible human carcinogen Limited evidence from animal studies and inadequate or no data in humans.
Group D: Not classifiable
Group E: No evidence of carcinogenicity

CHEMICAL INDEX (WATER)

APPENDIX E

MILITARY EXPOSURE GUIDELINES FOR SOIL

CONTENTS

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TABLE E-1. LONG-TERM, SOIL MILITARY EXPOSURE GUIDELINES (1 YEAR DEPLOYMENT)

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Acenaphthene 83-32-9	1300	NA	May cause slight changes in the liver.	Liver	Inhalation not included in derivation of this value (PAH). MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG.
Acenaphthylene 208-96-8	UD	D	As with other PAHs, toxicity following short-term exposure is minimal. Long-term exposure to PAHs can produce a variety of non-cancer effects including irritation of the eyes and photosensitivity, mild liver or kidney damage, anemia and other changes in the blood cells.	Liver, kidneys, blood, IMM	No data are available upon which to base guidelines for this chemical.; inhalation not considered in derivation of this value (PAH).
Acetone 67-64-1	16	D	Eye, nose and throat irritation, headache, dizziness, CNS depression, dermatitis.	Eyes, skin, RS, CNS	MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG.
Alachlor 15972-60-8	1000	B2	May damage the liver, kidney, and spleen; cancer.	Liver, kidneys, spleen	
Aldrin 309-00-2	3	B2	Nausea, vomiting, diarrhea, hyperexcitability, tremors, limb jerks, convulsions, and ventricular fibrillation; reversible kidney and liver injury; cancer.	CNS, liver, kidneys	Ingestion of 25.6 mg/kg BW can produce convulsions; a single oral dose of 5 g (71 mg/kg BW) is lethal.

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Anthracene 120-12-7	6.1	D	Contact may make the skin more susceptible to the effects of sunlight. Long-term exposure to PAHs can produce a variety of non-cancer effects including irritation of the eyes and photosensitivity, mild liver or kidney damage, anemia and other changes in the blood cells.	Liver, kidneys, blood, IMM, skin	Inhalation not considered in derivation of this value. MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG (PAH).
Aroclor-1016 12674-11-2	7.4	NA	Nausea, vomiting, liver damage, facial edema, abdominal pain, weight loss, diarrhea; headache, dizziness, depression, weakness, transient visual disturbances; chloracne; birth defects, peripheral nerve damage. Cumulative toxicity; liver and kidney damage.	CNS, liver, kidneys	PCB. Minimal oral dose expected to cause symptoms is 500 mg (7 mg/kg BW). Can be absorbed dermally – in one case of acute dermal exposure, a worker exposed to polychlorinated biphenyls developed hyperpigmentation, skin thickening and photosensitivity.
Aroclor-1254 11097-69-1	5.2	NA	Nausea, vomiting, liver damage, facial edema, abdominal pain, weight loss, diarrhea; headache, dizziness, depression, weakness, transient visual disturbances; chloracne; birth defects, peripheral nerve damage. Cumulative toxicity, liver and kidney damage.	CNS, liver, kidneys	Minimal oral dose expected to cause symptoms is 500 mg (7 mg/kg BW). Can be absorbed dermally – in one case of acute dermal exposure, a worker exposed to polychlorinated biphenyls developed hyperpigmentation, skin thickening and photosensitivity.

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Arsenic 7440-38-2	1100	A	Facial swelling, vomiting, loss of appetite, abdominal pain; diarrhea, shock, muscle cramps, headache, chill, cardiac abnormalities, decreased white blood cell count, and enlargement of liver; delayed effects include sensory and motor peripheral polyneuropathies. Hyperpigmentation of the skin (especially on the palms of the hands and soles of the feet), anemia, weakness, incoordination, mental confusion, cirrhosis of the liver, hair loss and nail changes; cancer.	Liver, kidneys, blood, CNS, GI tract, IMM	CHID under development.
Benzene 71-43-2	310	A	Vomiting, loss of coordination, light-headedness, headache, anemia, shallow/rapid pulse, loss of concentration, delirium, chemical pneumonitis, dizziness, pallor, flushing, weakness, and breathlessness; high concentrations may cause convulsions, coma, or irregular heart beat. Fatigue, headache, dizziness, nausea, loss of appetite, weakness, nosebleeds, pallor, and bleeding gums; bone marrow damage; immunosuppression; cancer.	Eyes, skin, RS, blood, CNS, IMM, HEM	The mean lethal oral dose has been estimated to be 13 g (186 mg/kg BW). Acute erythema, blistering and dermatitis may develop from dermal exposure; skin absorption from acute dermal exposure can cause CNS effects. CHID under development.

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Benzo(a)anthracene 56-55-3	2500	B2	As with other PAHs, toxicity following short-term exposure is minimal. Long-term exposure to PAHs can produce a variety of non-cancer effects including irritation of the eyes and photosensitivity, mild liver or kidney damage, anemia and other changes in the blood cells. Skin contact may cause irritation, erythema (redness), warts or polyps, and skin cancer.	Liver, kidneys, blood, IMM	Inhalation not considered in derivation of this value. MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG (PAH).
Benzo(a)pyrene 50-32-8	250	B2	Toxicity from short-term exposure is low. Long-term exposure may cause depression of the immune system; mild liver or kidney damage; changes in the blood composition such as aplastic anemia and pancytopenia; and cancer. Effects on the developing fetus have been observed in laboratory animals.	Liver, kidneys, blood, IMM	Inhalation not considered in derivation of this value. MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG (PAH).
Benzo(b)fluoranthene 205-99-2	2500	B2	Toxicity from short-term exosure is low. Long-term exposure may cause depression of the immune system; mild liver and kidney damage; anemia and other changes in the blood cells; and cancer. Skin contact may cause irritation, erythema (redness), warts or polyps, and skin cancer.	Liver, kidney, blood, IMM	Inhalation not considered in derivation of this value. MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG (PAH).

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Benzo(k)fluoranthene 207-08-9	3100	B2	Toxicity from short-term exosure is low. Long-term exposure may cause depression of the immune system; mild liver and kidney damage; anemia and other changes in the blood cells; and cancer. Skin contact may cause irritation, erythema (redness), warts or polyps, and skin cancer.	Liver, kidney, blood, IMM	Inhalation not considered in derivation of this value. MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG (PAH).
Beryllium 7440-41-7	16000	B2	Low acute toxicity by ingestion. Rickets (fragile or weakened bones); cancer.	Bone	Evidence of carcinogenicity from inhaled beryllium.
Bis (2-ethylhexyl) phthalate 117-81-7	2900	B2	Eye irritation, liver damage, possible teratogenic and carcinogenic effects.	Eyes, skin, RS., CNS, liver, REPR, GI tract	
Sec-Butylbenzene 135-98-8	230	NA	Irritation of eyes, nose, throat, and skin, CNS depression, incoordination, nausea, general anesthetic effects.	Eyes, RS, skin	MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG.
Cadmium 7440-43-9	130	B1	Nausea, vomiting, diarrhea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock, and renal failure. Pain resulting from softening or decalcification of the bones, osteoporosis, irreversible kidney disease, anemia; cancer.	Kidneys, liver	Ingestion of 3 mg (0.043 mg/kg BW) may cause vomiting; 30 mg (0.43 mg/kg/ BW) of soluble cadmium salts can produce severe toxic symptoms; 350 mg (5 mg/kg BW) may be fatal.

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Carbon disulfide 75-15-0	720	NA	Dizziness, headache, nausea, vomiting, diarrhea, fatigue, palpitations and weakness; high concentrations may cause psychosis, tremor, delirium, coma, muscle spasm, convulsions, difficulty breathing, and liver damage. Decreased fertility in males and females.	CNS, PNS, liver, REPR	Systemic effects can occur from skin absorption following severe skin irritation. MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG.
Chlordane 57-74-9	62	B2	Nausea, vomiting, diarrhea, headache, excitability, confusion, weakness, incoordination; high concentrations may cause delirium, muscle spasms, convulsions or seizures, coma, pulmonary edema, and difficulty breathing. Kidney and liver degeneration; blood dyscrasias; cancer.	CNS, liver, kidneys	Ingestion of 28 to 56 mg/kg BW may cause severe effects such as convulsions. The fatal human dose lies between 6 and 60 g. The onset of symptoms occurs 45 minutes to several hours after ingestion. Can be absorbed through the skin.
Chloromethane (Methyl chloride) 74-87-3	3700	C	Headache, drowsiness, giddiness, dizziness, confusion, incoordination, vomiting, abdominal pain, diarrhea, breathing difficulties; high concentrations may cause unconsciousness, convulsions, coma, visual disturbances, and may damage the kidneys, liver, or blood; cancer.	CNS, liver, kidneys, REPR	Symptoms of chloromethane exposure may be delayed in onset. Bronchospasm can develop from constant skin absorption.

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Chlorothalonil 1897-45-6	1500	B2	Vomiting, rapid breathing, GI irritation, weakness, and sedation. Cumulative toxicity; incoordination, rapid breathing, hematuria (blood in the urine), nosebleed, delayed hypersensitivity; cancer.	CNS, GI tract, UT	
Chromium (total) 7440-47-3	5700	D	The toxicity of chromium has been attributed primarily to hexavalent chromium compounds.	Kidneys, liver	
Chromium III 16065-83-1	390000	D	Hexavalent chromium compounds are more toxic than trivalent chromium compounds.	Kidneys, liver	
Chromium VI 18540-29-9	5300	A	Ingestion of hexavalent chromium compounds may cause GI irritation, epigastric pain, nausea, vomiting, diarrhea, liver and kidney damage, internal bleeding, circulatory collapse, unconsciousness, and death. Reduced fertility and birth defects are possible; cancer.	Kidneys, liver	Doses of 0.5 – 1.5 g (7-21 mg/kg) BW $K_2Cr_2O_7$ have been fatal. Carcinogenic via inhalation; carcinogenicity via oral ingestion cannot be determined and is classified as Group D.

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Chrysene 218-01-9	3100	B2	Toxicity from short-term exposure is low. Long-term exposure may cause depression of the immune system; mild liver and kidney damage; anemia and other changes in the blood cells; and cancer. Skin contact may cause irritation, erythema (redness), warts or polyps, and skin cancer.	Liver, kidneys, blood, IMM	Inhalation not considered in derivation of this value. MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG (PAH).
Cumene 98-82-8	640	D	Irritation to eyes, skin, mucous membranes; dermatitis; headache, narcosis, coma.	CNS, URS, eyes, skin	MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG.
Cyanide 57-12-5	110000	D	Headache, breathlessness, weakness, palpitation, nausea, vomiting, giddiness, tremor, rapid heart beat, dizziness, confusion, anxiety, agitation, confusion, cardiac arrhythmias, seizures, stupor, and coma. CNS effects (insomnia, memory loss, tremors); degeneration of spinal cord and optic nerve; enlargement of the thyroid gland; reduced fertility and birth defects are possible.	CNS, RS, CVS, liver, kidneys	Concentrations between 0.9 and 1.7 mg/kg BW may cause changes in blood chemistry without clinical effects. Severe but reversible symptoms may occur at concentrations of 1.7 to 3.4 mg/kg BW; concentrations higher than 3.4 mg/kg BW life-threatening toxicity.

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
2,4-D (2,4-Dichlorophenoxyacetic acid) 94-75-7	1000	D	Nervous system damage, vomiting, diarrhea, lethargy, incoordination, weakness, paralysis, stupor, miosis, stiffness in the extremities, muscle twitching and spasms , lowered blood pressure, convulsions; transient liver and kidney damage; may cause birth defects and reduced fertility. Cumulative toxicity; CNS, kidney, and liver damage.	CNS, liver, kidneys	Ingestion of a single dose of 5 mg/kg BW and repeated doses of 7 mg/kg /day for 21 days caused no effects. The single oral lethal dose has been estimated to be 355 mg/kg BW. Survival following a dose of about 110 mg/kg BW has been reported. May be dermally absorbed.
P,p'-DDT 50-29-3	52	B2	Vomiting, tingling of lips, tongue, and face; malaise, headache, sore throat, fatigue, tremors; apprehension, ataxia, confusion, convulsions, coma and partial paralysis. Estrogenic effects; may reduce fertility; cancer.	Eyes, skin, CNS, kidneys, liver, PNS	
Diazinon 333-41-5	52	E	Nausea, vomiting, diarrhea, headache, dizziness, weakness, excessive tearing and salivation, ocular pain, blurring/dimness of vision, miosis, loss of muscle coordination, slurred speech, muscle twitching, disorientation, drowsiness, difficulty breathing, hypertension, hypotention, cardiac arrhythmias, random jerky movements, incontinence, convulsions, and coma. Cumulative toxicity; loss of visual acuity.	Eyes, RS, CNS, CVS, blood, ChE Inh	Is efficiently absorbed through skin.

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Dibromochloropropane 96-12-8	210	B2	GI distress; may damage the kidney, liver, and testes. Kidney and liver damage, atrophy of the testes and sterility in males; cancer.	Liver, CNS, kidneys, spleen, REPR, GI tract	
Dieldrin 60-57-1	5.2	B2	Early signs of toxicity are headache, dizziness, nausea, vomiting, malaise, sweating, tremors, limb jerks, EEG changes, convulsions, and coma; secondary effects include hypertension, cardiac arrhythmias, and fever; sleep, memory, behavioral disturbances, headache, and convulsions may persist for months following exposure. Cumulative toxicity; fainting, muscle spasms, tremors, weight loss, reduced psychomotor skills, hemolytic anemia; reproductive effects may occur; cancer.	CNS	No effects were seen in volunteers given doses of 0.21 mg. Serious effects may occur at a dose of 10 mg/kg BW; 29 mg/kg BW caused profuse vomiting or prolonged convulsions; the acute mean lethal dose for humans has been estimated to lie between 20 and 70 mg/kg BW. Oral doses of dieldrin ranging from 10 to 211 ?g over a period of 18 months had no adverse effects in volunteers. Dieldrin is readily absorbed through skin.
Dinitrobenzene (1,3-) 99-65-0	450	D	Methemoglobinemia associated with headache, irritability, dizziness, weakness, nausea, lethargy, shortness of breath, liver damage. May cause reduced fertility and birth defects.	Blood, liver, CNS, CVS	The lethal dose has been estimated to lie between 5 and 50 mg/kg BW. It is readily absorbed through skin; acute dermal exposure can cause yellowing of skin.

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Dinoseb 88-85-7	100	D	Nausea, vomiting, abdominal pain, marked thirst, fatigue, sweating, facial flushing, rapid heart beat, fever, weight loss, respiratory distress, cyanosis, restlessness, anxiety, muscle cramps, excitement, convulsions, and coma. Liver or kidney damage; cataracts; may affect fertility.	CNS, REPR	
Disulfoton 298-04-4	30	NA	Headache, loss of appetite, nausea, vomiting, abdominal cramps, diarrhea, weakness, dizziness, confusion, slurred speech, salivation, tearing, profuse sweating, shortness of breath, tightness of the chest, changes in heart rate, cyanosis, moisis, blurred vision, runny nose, slow pulse, muscle twitching, tremors, muscle cramps, incoordination, convulsions, coma, and shock. Decreased visual acuity, liver injury, altered tendon reflexes.	Eyes, RS, CNS, CVS, ChE Inh	Oral doses of 0.75 mg/day for 30 days produced no significant effects in volunteers. The human LD_{50} has been estimated to be 5 mg/kg BW.
Endrin 72-20-8	45	D	Headache, dizziness, nausea, vomiting, hypersalivation, insomnia, lethargy, weakness, agitation and confusion; high concentrations may cause convulsions, stupor, tremors, and coma; headache, dizziness, sleepiness, weakness, and loss of appetite may persist for 2 to 4 weeks.	CNS	Convulsions may be induced in humans by doses of 0.2 to 0.25 mg/kg BW; a dose of 1 mg/kg can induce repeated seizures. Endrin can be absorbed through the skin.

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Ethyl benzene 100-41-4	230	D	Headache, nausea, weakness, dizziness, sleepiness, fatigue, loss of coordination, and coma.	CNS	MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG.
Ethylene dibromide 106-93-4	0.37	B2	Liver and kidney damage, vomiting, excitement and other CNS effects; may affect fertility in males; cancer.	CNS, liver, kidneys, REPR	A single oral dose of 65 mg/kg BW may be lethal. May be absorbed through skin.
Fenamiphos 22224-92-6	52	D	Nausea, vomiting, abdominal cramps, diarrhea, salivation, headache, dizziness, weakness, runny nose, blurred vision, constricted pupils, incoordination, slurred speech, muscle twitches, random jerky movements, mental confusion, disorientation, drowsiness, difficulty breathing, cardiac irregularities, incontinence, convulsions, and coma. Cumulative toxicity.	CNS, CVS, ChE Inh	May be absorbed through the skin.
Fluoranthene 206-44-0	42000	D	Toxicity from short-term exposure is low. Long-term exposure may cause depression of the immune system; mild liver and kidney damage; anemia and other changes in the blood cells. Skin contact may cause irritation, erythema (redness), warts or polyps.	Liver, kidney, blood, IMM	Inhalation not considered in derivation of this value
Fluorene 86-73-7	90	D	Eye or skin irritation.	Skin, eyes	MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG.

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Fonofos 944-22-9	220	D	Loss of appetite, nausea, vomiting, abdominal cramps, diarrhea, headache, dizziness, weakness, confusion, blurred vision, constricted pupils, slurred speech, profuse sweating, salivation, and runny nose; cardiac irregularities, difficulty breathing, muscle twitching, paralysis, convulsions, coma, or respiratory arrest may occur. Nervous behavior, tremors, liver damage, GI effects, increased nasal, salivary and lacrimal secretions.	CNS, CVS, ChE Inh	May be absorbed through the skin.
GA (TABUN) 77-81-6	4.6	NA	Nausea, vomiting, abdominal cramps, diarrhea, headache, giddiness, dizziness, weakness, excessive tearing, blurred or dim vision, miosis, loss of muscle coordination, slurred speech, muscle twitching, confusion, disorientation, drowsiness, difficulty breathing, excessive salivation, cardiac arrhythmias, random jerking movements, incontinence, convulsions, coma.	CNS, ChE Inh	See Table C-1 for additional info
GB (Sarin) 107-44-8	2.7	NA	SEE GA	SEE GA	See Table C-1 for additional info
GD (Soman) 96-64-0	0.27	NA	SEE GA	SEE GA	See Table C-1 for additional info

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Heptachlor 76-44-8	2	B2	Nausea, vomiting, diarrhea, kidney and liver damage; hyperexcitability, tremors, convulsions, and paralysis. Cumulative toxicity; blood dyscrasias. Reduced fertility has been observed in animal studies; cancer.	CNS, liver	A dose of 1 to 3 g has been estimated to cause serious symptoms in humans, especially liver impairment; can be absorbed through skin; estimated dermal toxicity for single exposure is 46 g (657 mg/kg BW) and 1.2 g/day (17 mg/kg BW) for multiple exposure.
Heptachlor epoxide 1024-57-3	1.5	B2	Apprehension, agitation, muscle twitching and spasms, tremor, incoordination, vomiting, GI upset, abdominal pain; convulsions; kidney injury and liver damage; cancer.	CNS, liver	
Hexachlorobenzene 118-74-1	31	B2	Headache, nausea, cyanosis, muscle spasm, convulsions, liver injury, birth defects. Porphyria cutanea tarda, enlargement of the thyroid and lumph nodes, reduced bone density, skin photosensitization, liver, kidney, and lung damage; cancer.	CNS, blood, liver, kidneys	

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Lead 7439-92-1	2200	B2	Loss of appetite, malaise, insomnia, headache, irritability, muscle and joint pains, cramping abdominal pain, tremors, hallucinations, distorted perceptions, muscle weakness, gastritis, skin pallor due to anemia, and dark gray-blue lines of lead sulfide visible in gums. Hypertension, irreversible kidney damage; may affect fertility and reproduction (fetal effects); cancer.	CNS, blood, kidneys, GI tract, CVS; REPR, fetus	Continuous long-term ingestion exposure through soil to levels exceeding this MEG may result in blood lead levels greater than 30 ug/dl, which is the OSHA recommended level for individuals planning to have children. However, OSHA allows 40 ug/dl as a "permissible" blood lead level in exposed workers below which no further medical monitoring or workplace intervention is required. The MEG of lead is based on USEPA's recommendation for nonresidential soil cleanup level (range 2000-5000 ppm) since toxicity information is currently unavailable. (Check: TSCA, Section 403). CHID under development.
Lead (Tetraethyl) 78-00-2	0.026		Anxiety, irritability, insomnia, nightmares, lack of appetite, nausea, vomiting, diarrhea, headache, muscle weakness, restlessness, visual difficulties, fatigue, bradycardia, hypotension, delusions, incoordination, mania, psychosis, hallucinations, convulsions, coma, and death; reproductive effects may be possible. Cumulative toxicity, ataxia, tremors, polyneuropathy.	CNS	
Lewisite 542-25-3	11	NA*	Nausea, vomiting, diarrhea, abdominal pain, intense thirst, restlessness, weakness, hypotension, and hypothermia.	GI tract, heart, brain, kidneys	Breakdown of lewisite is rapid in the environment; lewisite and degradation products contain arsenic which is carcinogenic (see arsenic).

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Lindane 58-89-9	560	C	Irritability, restlessness, insomnia, anxiety, dizziness, malaise, headache, nausea, fever, cyanosis, vomiting, and loss of muscle coordination; higher exposure can cause muscle spasms, seizures, and convulsions. Liver and kidney damage; may affect fertility; cancer.	CNS, REPR	The mean lethal dose is approximately 400 mg/kg BW. Can be absorbed through the skin.
Malathion 121-75-5	2200	D	Miosis, blurred vision, tearing, increased salivation, weakness, nausea, vomiting, abdominal cramps, diarrhea, giddiness, confusion, loss of muscle coordination, runny nose, headache, chest tightness, difficulty breathing, pulmonary edema, muscle twitching, coma, respiratory distress, cardiac irregularities, and convulsions. Chronic exposures can cause fatigue, visual disturbances, headache, nausea, abdominal pain, and twitching; kidney and liver damage; may affect fertility.	Lungs, liver, CNS, heart, ChE Inh	No effects were seen in volunteers after a single oral dose of 0.84 mg/kg BW or repeated doses of 16 mg/day BW for 47 days. The fatal dose is believed to be between 350-1000 mg/kg BW.

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Mercury (inorganic) 7439-97-6	33	D	Tremors, peripheral neuropathy, fatigue, memory loss, personality changes, kidney damage, cough, chest pain, difficulty breathing, liver damage, diarrhea, nausea, vomiting. Reduced visual acuity, tremor, ataxia, nerve fiber degeneration, loss of taste, smell, change in motor function, loss of higher mental function, irritability, headache, fatigue, weakness, loss of memory, depression, insomnia, apathy, hallucinations, seizures, mania; birth defects, kidney damage, dementia.	CNS	Dermal exposure can lead to systemic toxicity particularly if the skin is broken.
Mercury (Methyl) 22967-92-6	31	C	Paresthesia, impaired hearing, taste and smell; slurred speech, unsteady gait, muscle weakness, irritability, memory loss, depression, insomnia, ataxia, loss of visual acuity, tremors, confusion, hallucinations, excitement, loss of consciousness; nerve degeneration. Reproductive effects are possible; cancer.	CNS, kidneys	Single oral doses of 10-60 mg/kg BW have been fatal. Methyl mercury can be dermally absorbed.
Methyl ethyl ketone 78-93-3	34000	D	Irritation, CNS, reproductive effects.	Fetus, CNS	MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG.

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Methyl parathion 298-00-0	310	D	Nausea, vomiting, abdominal cramps, diarrhea, salivation, headache, weakness, giddiness, dizziness, runny nose, blurred vision, miosis, cardiac arrhythmias and ischemia, difficulty breathing; muscle twitch, convulsions, liver and kidney damage, coma and respiratory paralysis are possible at high concentrations. Cumulative toxicity.	Eyes, CNS, CVS, liver, kidneys, ChE Inh	Volunteers receiving oral doses of 22 mg/day suffered no ill effects. Depression of red blood cell cholinesterase occurred at doses of 30 mg/day which was considered to be the level of minimal toxicity. Ingestion of 50 to 200 g has resulted in death; the minimum adult lethal dose by the oral route may be less than 1.84 g. Can be absorbed through the skin.
Molybdenum 7439-98-7	1300	NA	Weight loss, diarrhea, poor muscle coordination, headaches, muscle or joint aching. Changes in liver function, gout, anemia.	Liver, kidneys, blood	
Naphthalene 91-20-3	220	C	Headache, profuse perspiration, confusion, listlessness, lethargy, muscle twitching, coma; nausea, vomiting, abdominal cramps, diarrhea; hemolytic anemia, methemoglobinemia; cataracts, liver and kidney damage.	Eyes, blood, liver, kidneys, CNS	MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG (PAH).
Oxamyl (Vydate) 23135-22-0	3000		Tremors, blurred or dim vision, increased salivation, tearing, incontinence, diarrhea, abdominal cramps, nausea, vomiting, and difficulty breathing; convulsions, coma, and respiratory paralysis are possible at high concentrations; protracted malaise and weakness may persist after apparent recovery.	ChE Inh	

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Paraquat 1910-42-5	1100	C	Abdominal cramping, nausea, vomiting, bloody diarrhea, headache, difficulty swallowing, fever, decreased blood pressure; higher concentrations can cause heart, kidney and liver injury and extensive lung damage with difficulty breathing, pulmonary fibrosis and edema; may reduce fertility in males. Edema, interstitial bleeding; lung, kidney, and liver damage; cancer.	Lungs, liver, kidneys, GI tract	Single oral doses of 1 to 4 g have caused fatalities.
Phenanthrene 85-01-8	270	D	Contact may make the skin more susceptible to the effects of sunlight (photosensitization). As with other polycyclic aromatic hydrocarbons (PAHs), toxicity following short-term exposure is low. Long-term exposure to PAHs can produce a variety of non-cancer effects including irritation of the eyes and photosensitivity, mild liver or kidney damage, anemia and other changes in the blood cells, and immunosuppression.	Liver, kidneys, blood, IMM, skin	Inhalation not considered in derivation of this value. MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG (PAH).

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Polychlorinated biphenyls 1336-36-3	2.1	B2	Exposure may cause skin and mucous membrane irritation, skin hyperpigmentation, chloracne, headache, abnormal liver function tests, hepatomegaly, malaise, peripheral neurotoxicity, liver disease and cirrhosis. Swelling of the face and eyelides, transient visual disturbances, hypothyroidism, GI distress, jaundice, and nephrotoxicity have also been reported.	PNS, liver, kidneys	
n-Propylbenzene 103-65-1	240	D	Irritation of eyes, nose, throat, and skin, CNS depression, incoordination, nausea, general anesthetic effects.	Eyes, RS, skin	MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG (PAH).
Pyrene 129-00-0	31000	D	Pyrene is irritating to exposed skin and eyes. Contact may make the skin more susceptible to the effects of sunlight. As with other polycyclic aromatic hydrocarbons (PAHs), toxicity following short-term exposure is low. Long-term exposure to PAHs can produce a variety of non-cancer effects including irritation of the eyes and photosensitivity, mild liver or kidney damage, anemia and other changes in the blood cells, and immunosuppression.	Liver, kidneys, blood, IMM, skin	Inhalation not considered in derivation of this value. Refer to 1-year Air-MEG (PAH).

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Simazine 122-34-9	520	C	Incoordination, tremor, weakness, muscle spasms, difficulty breathing; cancer.	CNS, kidneys, liver	
Strontium 7440-24-6	140000	NA	Skin and eye irritation, altered heart function, bone abnormalities.	Bone, heart, skin, eyes	
Sulfur Mustard (HD) 505-60-2	0.51	A	Powerful skin irritation and blistering, severe eye injury, permanent loss of vision. Nausea, vomiting, and diarrhea can follow ingestion.	Eyes, skin, GI tract	Effects (e.g skin/eye irritation) are generally delayed 2-24 hours post exposure); any suspected exposure should be addressed by immediate and thorough decontamination (such as rinsing with 0.05 % bleach/water solution)
TCDD (2,3,7,8-) 1746-01-6	0.0048	B2	Headache, nausea, vomiting, severe muscle pain, liver damage, chloracne, porphyria cutanea tarda, hair loss, hyperpigmentation, polyneuropathy, neurobehavioral effects, possible immunosuppression, thymic atrophy, liver damage. Cumulative toxicity; cancer.	Liver, skin, kidneys, blood, REPR	Single oral lethal doses have been estimated to be greater than 100 ?g/kg BW. The minimum cumulative toxic dose has been estimated to be 0.1 ?g/kg BW.

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Terbufos 13071-79-9	2.6	NA	Nausea, vomiting, abdominal cramps, diarrhea, excessive salivation, headache, dizziness, weakness, excessive tearing and salivation, ocular pain, blurred vision, constricted pupils, incoordination, slurred speech, muscle twitches, mental confusion, drowsiness, difficulty breathing, cyanosis, cardiac irregularities, incontinence, convulsions, and coma. Cumulative toxicity is possible.	CNS, CVS, ChE Inh	
Toluene 108-88-3	520	D	Fatigue, nausea, weakness, confusion; higher concentrations can cause headache, vomiting, diarrhea, depressed respiration, loss of muscle coordination.	CNS	MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG.
Toxaphene 8001-35-2	100	B2	Salivation, restlessness, hyperexcitability, tremors, spasms and convulsions. Liver and kidney degeneration; possible immune system suppression; cancer.	CNS	The acute oral LD_{50} has been estimated to be 60 mg/kg BW. Can be absorbed through the skin; skin absorption is enhanced by oils.
Trifluralin 1582-09-8	740	C	Liver and kidney changes, anemia, CNS depression. Occasional vomiting, kidney and liver damage; decreased kidney and liver damage; decreased white and red blood cell counts; cancer.	CNS, liver, kidneys, blood	

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Trimethylbenzene (1,2,4-) 95-63-6	5190	NA	Irritation of skin, eyes, nose, throat, bronchitis, anemia, drowsiness, fatigue, nausea	Eyes, skin, RS, CNS, blood	MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG.
Trimethylbenzene (1,3,5-) 108-67-8	5190	NA	Irritation of skin, eyes, nose, throat, bronchitis, anemia, drowsiness, fatigue, nausea	Eyes, skin, respiratory system, CNS, Blood	MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG.
Vanadium 7440-62-2	1600	NA	Vanadium salts can cause abdominal cramping, diarrhea, black stools, and green tongue; bone marrow depression leading to changes in numbers of white and red blood cells. High concentrations can cause tremors, headache, and tinnitus. Irregular or slow heartbeat, kidney damage.	Kidneys, CNS, HEM	Metallic vanadium has low oral toxicity. It is ubiquitous in soils and approximately 20 ?gs are normally ingested daily. However, ingestion of 60-120 mg of a vanadium salt may be fatal. Pentavalent forms and vanadates are the most toxic. The effects shown in the table are primarily those of vanadium salts.
VX 50782-69-9	0.079	NA	Nausea, vomiting, diarrhea, abdominal cramps, headache, giddiness, dizziness, excessive salivation, tearing, miosis, blurred or dim vision, miosis, difficulty breathing, cardiac arrhythmias, loss of muscle coordination, muscle twitching, random jerking movements, convulsions, coma.	CNS, ChE Inh	See Table C-1 for additional info

Chemical CAS No.	1-yr soil MEG (mg/kg)	Cancer Class	Potential Symptoms †	Target Organs and Systems	Notes §
Xylene 1330-20-7	210	D	Headache, weakness, dizziness, confusion, nausea, vomiting, abdominal pain, shivering, incoordination, loss of appetite, tremors, disturbed vision, salivation, and difficulty breathing; liver and kidney damage, and cardiac arrhythmias are possible.	CNS, liver, kidneys, blood, GI tract	MEG based on Csat. At this level, inhalation is the most probable route of exposure. Refer to 1-year Air-MEG.
Zinc 7646-85-7	69000	D	Severe stomach irritation, nausea, vomiting, and diarrhea (for zinc chloride).	GI tract	

Footnotes on next page.

FOOTNOTES FOR TABLE E-1 SOIL-MEG VALUES

§ This column shows oral doses that have been estimated to cause the indicated toxic effects. The term BW was added to reported doses to differentiate between mg/kg of BW (70 kg) and mg/kg soil as shown in the "MEG" Column. Chemicals that can be absorbed through the skin are also noted in this column. Unless otherwise noted, any dermal toxicity listed in this column is based on acute dermal exposures. Estimated lethal doses and approximate toxic effect levels were obtained from the TOMES database software system, from Gosselin, et al (1976), from Hayes, *Pesticides Studies in Man*, and from the USEPA Health Advisory Source documents. Information on health effects resulting from dermal exposure was obtained from the TOMES database (intranet/DVD version; expires January 2000), see RD230.

Csat – Soil saturation concentration, the highest concentration expected in soil due to the volatility of the substance.
CHID – Chemical Hazard Information for Deployments. Additional Fact Sheet information is under development for notated Chemicals..
BW – Body weight
EEG – electroencephalogram (brain waves)
LC_{Lo} – Lethal Concentration – low (estimate of small percentage (e.g. 1-5 %) exposed will succumb lethally
MRL – Minimum Risk Level
NA – Not Available;
PAH – Polycyclic Aromatic Hydrocarbon

TABLE 2-4-1. TARGET ORGANS

TARGET ORGANS	
Eyes	Brain
Skin	Heart
Blood	Pancreas
Bladder	Adrenal Glands
Thyroid	Lungs
Bone	Liver
Fetus	Kidneys
Spleen	

TABLE 2-4-2. TARGET SYSTEMS

TARGET SYSTEMS	
CNS – Central Nervous System	CVS – Cardiovascular System
PNS – Peripheral Nervous System	ChE Inh – Cholinesterase Inhibitor
GI tract – Gastrointestinal Tract	UT – Urogenital Tract
RS – Respiratory System	CRC – Circulatory System
LRS – Lower Respiratory System	IMM – Immune System
URS – Upper Respiratory System	REPR – Reproductive System
ENDO – Endocrine System	HEM – Hemopoietic System
LYMP – Lymphatic System	

Units used:
µg/kg = micrograms per kilogram = ppb = parts per billion
mg/kg = milligram per liter = ppm = part per million
mg/kg/day == milligram chemical per kilogram body weight (ingested) per day

Cancer Class Categories:
The scheme used by the USEPA for categorizing chemicals according to their carcinogenic potential is as follows (see Section 2.4.3):
Group A: Human carcinogen
Group B: Probable human carcinogen:
Group B1 - Limited evidence in epidemiological studies
Group B2 - Sufficient evidence from animal studies
Group C: Possible human carcinogen Limited evidence from animal studies and inadequate or no data in humans.
Group D: Not classifiable
Group E: No evidence of carcinogenicity

CHEMICAL INDEX (SOIL)

APPENDIX F

HYPOTHETICAL CASE STUDIES

The purpose of these hypothetical case studies is to illustrate how preventive medicine personnel can use the Military Exposure Guidelines (MEGs) as a tool to support operational risk management activities. These case studies are not designed to specifically represent real-life situations, but to demonstrate how, given certain information, the MEGs can be used in context with environmental data. The reference tables are provided as quick references for use during review of the case studies.

REFERENCE TABLES

CASE STUDIES

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TABLE F-1. EXAMPLE OEH CHEMICAL RISK ASSESSMENT SUMMARY TABLE

CHEMICAL HAZARD	HAZARD RANKING			OPERATIONAL RISK ESTIMATE		PREDICTED HEALTH OUTCOME		CONTROLS & NOTES
	HAZARD TYPE	HAZARD PROBABILITY	HAZARD SEVERITY	RISK LEVEL	CONFIDENCE	DURING DEPLOYMENT	AFTER DEPLOYMENT	
						Symptoms: Incidence:	Symptoms: Incidence:	

TABLE F-2. CHEMICAL HAZARD SEVERITY RANKING CHART FOR MILITARY DEPLOYMENTS

MAGNITUDE OF CHEMICAL CONCENTRATION	**WATER**	< MEG	= MEG that is not based on TB MED 577 (See Water Note)		= MEG that is based on TB MED 577 (See Water Note)	See Water Note	See Water Note
	SOIL	< MEG	= MEG (See Soil Note)		See Soil Note	See Soil Note	See Soil Note
	AIR	< 1-yr MEG or < 14-day MEG	= 1-yr MEG or = 14-day MEG but = 1 to 24-hr Min-MEGs	≥ 1-yr MEG or ≥14-day MEG but > 1 to 24-hr Min-MEGs	> 1-hr Min-MEG but ≤ 1-hr Sig-MEG	>1-hr Sig-MEG but = 1-hr Sev-MEG	> 1 hr Sev-MEG
IN GENERAL, THE ASSOCIATED HEALTH OUTCOME ATTRIBUTIBLE TO EXPOSURE (Percentages are very uncertain and will vary by chemical and other confounding factors.)		No cases of illness or non-cancer disease and less than 1 cancer case in 10,000	0 – 10 % of personnel may develop illness or chronic disease	0 – 10 % of personnel may develop mild illness or temporary irritation	> 10 % of personnel may experience mild illness, irritation AND 0 – 10 % of personnel may develop more severe illness that begins to impair functional abilities.	10 – 25 % of personnel may experience severe illness or irritation and more noticeable degradation of performance capabilities AND Other personnel will, at least, suffer some mild effects	> 25 % of personnel may experience severe, incapacitating effects AND Fatalities will begin to occur just above the Sev Air-MEG with increasing number of fatalities as concentrations increase
ONSET OF SYMPTOMS		After the Mission		During the Mission			
HAZARD SEVERITY RANK		NONE	NEGLIGIBLE		MARGINAL	CRITICAL	CATASTROPHIC
HAZARD TYPE		NO HEALTH THREAT	HEALTH THREAT		MEDICAL THREAT		

WATER NOTE: Concentrations greater than the MEG *may* result in Hazard Severity from Marginal to Catastrophic if certain chemicals are present in high enough quantities and there is sufficient consumption. Additional information in the Notes column of the MEG Tables should be evaluated regarding impacts of higher levels of exposure.

SOIL NOTE: Soil is unlikely to represent a hazard that would yield a Medical Threat. Additional information in the Notes column of the MEG Tables should be evaluated for data regarding higher levels of exposure.

TABLE F-3. CHEMICAL HAZARD PROBABILITY RANKING CHART FOR MILITARY DEPLOYMENTS

PERCENT OF PERSONNEL THAT WILL EXPERIENCE EXPOSURES TO CONCENTRATIONS EQUAL TO OR GREATER THAN THE MEG*				
<10%	10<25 %	25<50 %	50<75 %	>75 %
Unlikely	Seldom	Occasional	Likely	Frequent

*Determination of the percent of personnel exposed to a chemical or mixture specifically above a guideline level can be based on modeling, gridding, or generalized assumptions.

TABLE F-4. RISK ASSESSMENT MATRIX (FM 100-14)

HAZARD SEVERITY		HAZARD PROBABILITY				
		Frequent (A)	Likely (B)	Occasional (C)	Seldom (D)	Unlikely (E)
		?	**?**	**?**	**?**	**?**
Catastrophic (I)	**?**	Extremely High	Extremely High	High	High	Moderate
Critical (II)	**?**	Extremely High	High	High	Moderate	Low
Marginal (III)	**?**	High	Moderate	Moderate	Low	Low
Negligible (IV)	**?**	Moderate	Low	Low	Low	Low
		RISK ESTIMATE				

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CS-1 Wartime Chlorine Plume

MISSION AND ENVIRONMENTAL SETTING

You are the preventive medicine officer located at a central base camp during a wartime mission in Central America. Your responsibilities include transferring information to/from the field units in your area and making recommendations to higher headquarters. You have just received intelligence information about a factory located in proximity to one of your units.

PART A - INITIAL RISK ASSESSMENT

A-1. HAZARD IDENTIFICATION

Step A-1.1. METT-TC: Chemicals, Media, and Locations

The intelligence information includes the following:

- Various chemicals are stored at the factory; of particular concern is chlorine.
- Large amounts (tons) are stored, but it appears the plant is not operational.
- Enemy troops are aware of the unit's location.
- The mission of the at-risk unit requires it to continue maneuvering near (within 1 mile of the facility) and then beyond the chemical factory.
- Light winds are blowing toward the at-risk unit.

You realize that the stored chlorine could be used purposefully against U.S. personnel through bombing or other mechanisms resulting in the release of chlorine. If a chlorine-plume were to drift downwind toward the unit, then the troops would be exposed. The primary exposure routes of concern are inhalation and direct contact with the eyes and skin. You check the Air-MEG tables and establish the health effects associated with acute airborne/inhalation exposures to chlorine:

- Burning of eyes, nose, mouth, and respiratory system
- Excessive tearing, runny nose
- Coughing, choking, chest pain
- Nausea, vomiting
- Hypoxemia, dermatitis

You need to notify the unit of the situation. You realize that the commanding officer will want some initial description of the type of threat posed by this hazard.

Step A-1.2. Preliminary Threat Analysis

Currently, you have limited information as to both the anticipated concentrations (severity of hazard) as well as the probability that a release would even occur. Because of the known presence of the chemicals and the possibility of a release (accidental or purposeful), you notify your commander that such a chlorine plume would be a HEALTH THREAT to unit personnel and should be considered a possible MEDICAL

THREAT that could result in the degradation of the unit's capacity to accomplish their mission. You indicate that this is based on limited information and wish to validate this threat level by performing a risk assessment. Your commander indicates that there is limited time available but that if a Risk Level could be provided it would facilitate better Risk Management decisions such as whether this warrants moving unit locations.

A-2. HAZARD ASSESSMENT

You realize that plume concentration levels and locations after a release could be estimated with air dispersion models and that this would provide a more realistic basis for your assessment of associated risks. You don't have the capability to run such a model, however, and coordination with agencies such as USACHPPM, that do perform such tasks, will take more time than you have. So, even without quantitative data, you proceed through the risk assessment process based on the available information.

Step A-2.1. Hazard Severity Evaluation

Estimating hazard severity is particularly difficult in this situation. An explosion would very likely release a large amount of chlorine, but the amount of dissipation in the environment before reaching the unit is unknown. Based on the information in Appendix C, chlorine only has short-term Air-MEG and, therefore, it should be considered more of an immediate, acute hazard.

From the information in Appendix C, you decide that a chlorine plume can be quite dangerous and that exposures could significantly degrade the unit with the acute symptoms identified in Step A-1.1, or cause the unit to be completely disabled with the possibility of deaths. Therefore, you decide to conservatively estimate a severity range of CRITICAL to CATASTROPHIC.

Step A-2.2. Hazard Probability Evaluation

Available intelligence reports tell you that the enemy has the means and will to destroy the factory. Due to this battlefield environment, the S2 estimates that the probability of the enemy attacking the facility resulting in a chlorine-plume in the direction of the unit as likely. Based on this estimate, you predict that 50-75% of the unit could be exposed to chloride concentrations greater than the MEG, resulting in a hazard probability rank of LIKELY.

Step A-2.3. Risk Characterization

Table 1-A provides the risk characterization summary.

A-2.3.1 Risk Estimate

The above hazard rankings combine to present an operational risk of HIGH to EXTREMELY HIGH. This risk level forecasts a unit status of Red (Combat Ineffective) to Black (Requires Reconstitution), if the Command bases its decision framework on FM 101-5-1.

A-2.3.2 Confidence Level

You consider your confidence in the risk estimate to be LOW. This is based on the following attributes of the available information:

- Whether the enemy will sabotage the facility while the unit passes by is not known.
- If the factory is sabotaged, then the resulting chlorine concentrations in the plume cannot be predicted, as the size of the release and local climatic conditions will influence any exposures

?? A chlorine-plume scenario is plausible and the immediate health effects of excessive chlorine exposures are well known.

A-2.3.3 Threat Category

During Hazard Identification, you estimated that such a chlorine plume would be a health threat to unit personnel and should be considered a possible medical threat that could result in the degradation of the unit's capacity to accomplish their mission. During the Hazard Assessment, you based the hazard severity estimate of critical to catastrophic on the fact that a chlorine-plume can be quite dangerous and exposures could significantly degrade the unit with acute symptoms that render them incapacitated.

Therefore, according to guidance in the Chemical Hazard Severity Chart on Table F-2, you conclude that the threat category should be increased to a MEDICAL THREAT.

A-3. DEVELOP AND COMPARE CONTROLS FOR COA DEVELOPMENT

You notify the unit of your assessment and verify the unit's exact location and number of personnel. The only control available is to have the unit relocate. If the unit relocates far enough away from the downwind side of the facility, then the hazard is eliminated. A decision is made by the unit commander to have the unit relocate further away until further notice.

PART B - RE-ASSESSMENT OF RISK

B-1. HAZARD IDENTIFICATION

Step B-1.1. METT-TC: Chemicals, Media, and Locations

A short time later, you receive word that during the retreat back to base camp, the factory was bombed. Personnel had already moved away from the downwind side of the factory approximately one-half mile when the incident occurred. The commander of the unit has halted movement and is considering if the unit should prepare to turn back. The success of the mission requires movement forward, and since the hazard (the stored chlorine tanks) has been mitigated somewhat, and because an immediate, quick movement through the area may be unexpected, it would be an opportune time to proceed. You can appreciate the strategic benefits to this plan but caution the commander that residual contamination might present a hazard.

Step B-1.2. Revised Threat Analysis

You inform the commander that without information regarding dispersion and evaporation of the chlorine, residual air contamination may still be able to cause health effects that degrade personnel performance. As a result you still consider the hazard to be present, and consider this a HEALTH THREAT, with potential to be a MEDICAL THREAT.

B-2. HAZARD ASSESSMENT

The commander informs you that he has already dispatched a member of his unit with sampling equipment and protective gear to obtain real-time data from the area. A few minutes later this individual reports back via radio and states that air levels of chlorine are averaging about 4 ppm (10 mg/m^3).

Step B-2.1. Hazard Severity Evaluation

You check Appendix C and determine this to be just above the 1-hour significant-effect Air-MEG (2 ppm), and well below the severe-effect level 1-hour Air-MEG (22 ppm). Based on the suggested guidance in the Chemical Hazard Severity Ranking Chart in Table F-2, the hazard severity associated with measured concentrations greater than a Significant 1-hr MEG should be considered CRITICAL. The 1-hr significant MEG defines a "threshold" level for irreversible, permanent, or serious health effects that may result in performance degradation and incapacitate a small portion of individuals. Since the detected level (4 ppm) is substantially below the severe health effects MEG (22 ppm), you expect that a relatively small number of personnel would actually be affected to the point of more noticeable performance degradation, which may prevent them from quick maneuvering through the area.

Due to the small portion of the unit that you would expect to be affected significantly and the likely possibility that chlorine levels will likely be lower by the time personnel arrive at the area, you downgrade the severity rank from CRITICAL to MARGINAL, on the basis of professional judgment. In addition, dissipation of chlorine may bring the concentrations to levels less than the 1 hr Significant Air-MEG.

Step B-2.2. Hazard Probability Evaluation

You conclude that the probability of exposure to levels measured by the unit's reconnaissance will be LIKELY to OCCASIONAL while the unit passes through the area.

You did not select frequent because the Air-MEGs are for 1-hour average concentrations, not single grab samples (as was collected) and dissipation of the plume should continue.

Note: Such a decision must be based on professional judgment on a case-by-case basis. Dissipation of airborne chemicals is highly dependant upon the chemical in question, weather, terrain, and other site considerations.

Step B-2.3. Risk Characterization

Table 1-B provides the risk characterization summary.

B-2.3.1. Risk Estimate

The above hazard rankings combine to present an operational risk of MODERATE. This risk level forecasts a unit status of Amber (Mission Capable, with minor deficiencies), if the Command bases its decision framework on FM 100-14 and FM 101-5-1.

B-2.3.2. Confidence Level

You consider your confidence in the risk estimate to be MEDIUM; that is, for a chemical risk assessment, relatively high level of confidence.

Note: There are very few situations where a High degree of confidence would be reported due to the inherent limitations of our knowledge and simplistic assumptions of exposure processes and

toxicological/physiological/pharmocokinetic processes. For this assessment the degree of confidence is based on the following attributes of the available information:

?? Because the field measurement equipment is fairly accurate, data are considered good. However, the instrumentation is giving only a single point-in-time reference – the true levels that personnel would be exposed to are very possibly much less depending on time they take to get there and the meteorological conditions that impact the rate of chlorine dissipation.

?? Though not as weakly supported as some chemicals, the human toxicity estimates for chlorine have several uncertainties associated with them, usually addressed by safety factors or some degree of built-in conservatism.

B-2.3.3. Threat Category

The unit will be moving through the area of concern rapidly, which may mean less than a full hour of exposure, but there will be heavy exertion and increased breathing involved. At the detected levels, health effects are expected to be noticeable and in a small portion of the unit may be severe enough to significantly degrade performance abilities. The effects may continue after the exposure is eliminated. As such, as previous conclusion that the chlorine plume is a MEDICAL THREAT remains unchanged.

B-3. DEVELOP CONTROLS AND ASSESS RESIDUAL RISKS

Step B-3.1. Develop Controls

You discuss options with the unit commander. This includes:

1. No action and risk re-assessment at a later point in time with reanalysis;
2. Use of an alternate route circumventing the area of concern;
3. Use of the planned route using protective gear for personnel as they move through the area; or
4. Use of the planned route without protections; accepting the risk of health effects for within the unit.

Step B-3.2. Residual Risks

The commander considers risks associated with these options. Option 1 poses other risks because of the delayed time in an unsafe environment where enemy ambush is plausible. Option 2 has similar disadvantages because extending the mission with delays would also drain supplies/resources. For Option 3 to be viable, full-faced chemical-cartridge respirators (with chlorine cartridges) would need to be supplied immediately to the unit. This would not be possible due to the nature and location of the unit's operation. Additionally, such protective gear would inhibit movement, reduce visibility and communication capabilities, add to overall fatigue, and pose potential heat stress hazards. Choosing Option 4 would be an acceptance of the health and operational risks defined earlier. If the commander selects this option, then he/she must communicate this risk to his soldiers.

Step B-3.3. Actions to Increase Confidence in Risk Estimate

Because of the tactical necessity for making a quick decision, time does not allow for additional analyses to increase confidence in the analysis. No confidence-increasing actions are, therefore, recommended.

TABLE 1-A. PART A RISK ASSESSMENT SUMMARY AND RECOMMENDED CONTROLS

CHEMICAL HAZARD	HAZARD RANKING			OPERATIONAL RISK ESTIMATE		PREDICTED HEALTH OUTCOME		CONTROLS & NOTES
	HAZARD TYPE	HAZARD PROBABILITY	HAZARD SEVERITY	RISK LEVEL	CONFIDENCE	DURING DEPLOYMENT	AFTER DEPLOYMENT	
Possible Chlorine Plume	Medical Threat	Likely	Critical to Catastrophic	High to Extremely High	Low	Symptoms: Burning of eyes, nose, mouth, and respiratory system; excessive tearing, runny nose; coughing, choking, chest pain; nausea, vomiting; hypoxemia, dermatitis Incidence: 10-25%	Symptoms: Uncertain Incidence: Uncertain	Relocate Unit or No Action

TABLE 1-B. PART B RISK ASSESSMENT SUMMARY AND RECOMMENDED CONTROLS

CHEMICAL HAZARD	HAZARD RANKING			OPERATIONAL RISK ESTIMATE		PREDICTED HEALTH OUTCOME		CONTROLS & NOTES
	HAZARD TYPE	HAZARD PROBABILITY	HAZARD SEVERITY	RISK LEVEL	CONFIDENCE	DURING DEPLOYMENT	AFTER DEPLOYMENT	
Dissipating Chlorine Plume	Medical Threat	Likely to Occasional	Marginal	Moderate	Medium	Symptoms: Same as above, but should be less severe Incidence: 0-25%	Symptoms: Uncertain Incidence: Uncertain	1. Wait longer 2. Alternate route 3. Move out with PPE 4. Accept risk and move out

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CS-2 Cyanide in Proposed Water Supply

MISSION AND ENVIRONMENTAL SETTING

You are deployed very early in a peacekeeping operation. Base campsites are being selected and evaluated for follow-on forces as the mission expands. Planners have selected a location for a large base camp near a small city which has a municipal water supply. Logisticians want to use that municipal supply as a source of drinking water for the camp without having to rely on treatment by Army Reverse Osmosis Water Purification Unit (ROWPU) technology.

The test strip from your Water Quality Analysis Set – Preventive Medicine (WQAS-PM) indicates the presence of cyanide at concentrations around 4 milligrams per liter (mg/L). No other contaminants of concern were identified. The source of cyanide could be the deliberate use of hydrogen cyanide in the water as a chemical weapon, or the source could be one of several industries in the area.

1. HAZARD IDENTIFICATION

Step 1.1. METT-TC: Chemicals, Media, and Locations

Intelligence has indicated that the enemy has the capability to use cyanide as a chemical weapon and the municipal water supply is accessible. The municipal water supply has been abandoned and few industries in the area are operational. There are several industries in the vicinity that could have contaminated the surface water used by the municipal source.

Step 1.2. Preliminary Threat Analysis

Based on the peacekeeping operation, the mission may require the length of deployment to extend from 6-months to 1-year for personnel. The climate of the area fluctuates significantly throughout the year and reaches extreme temperatures in the summer months. Since personnel activities may require long work-shifts during the day when temperatures are extreme, you assume that many personnel will consume up to 15 L of water per day (per standard assumption pertaining to military personnel water consumption in TB MED 577).

You refer to the MEGs for cyanide in Appendix D (summarized below in Table 2-A). Guidelines are available for both temperate and arid climates for which standard practice are associated with assumptions of 5L/day and 15 L/day, respectively. Though several different exposure durations are represented, you note that the MEGs are the same for both short- and long-term durations. You also note, from the "Chemical" column of the table in Appendix D, that the MEGs for cyanide are actually TB MED 577 standards.

TABLE 2-A. MILITARY EXPOSURE GUIDELINES FOR CYANIDE IN WATER

Consumption Rate	5-day MEG (mg/L)	2-week MEG (mg/L)	1-year MEG (mg/L)
5 L/day	6	6	6
15 L/day	2	2	2

Since the detected concentration of 4 mg/L exceeds the 15 L/day cyanide drinking water MEG/TB MED 577 standard, as your preliminary threat analysis you determine that personnel exposure to cyanide from the municipal water supply is a HEALTH THREAT. You are not sure if the health effects would be significant enough to result in a medical threat. You notify your commander of the situation and that you are in the process of more specifically assessing the risks.

2. HAZARD ASSESSMENT

Step 2.1. Hazard Severity Evaluation

You have already established that the detected concentration of cyanide exceeds the 15 L/day MEG/TB MED 577 standard below which deployed military personnel drinking the municipal water should experience no adverse health effects for up to 1-year of consumption, assuming no other contamination and no increase in the cyanide concentration. You get more details by referring to the "Notes" column of Appendix D or the TB MED 577. The additional information from the "Notes" includes information regarding various concentrations of cyanide. This information is summarized below in Table 2-B.

TABLE 2-B. HEALTH EFFECTS FROM INGESTION OF CYANIDE IN DRINKING WATER

Consumption Rate	Safe Water Concentration (mg/L)	Changes in Blood Chemistry but no Clinical Effects (mg/L)	Metabolic Acidosis with Reversible Symptoms * (mg/L)	Life-threatening Toxicity (mg/L)
5 L/day	0-6	12-24	24-48	48+
15 L/day	0-2	4-8	8-16	16+

* For example: severe headaches, weakness, palpitation, nausea, giddiness and tremors.

Based on the Chemical Hazard Severity Ranking Chart for Military Deployments in Table F-2, the severity of cyanide exposures at concentrations around 4 mg/L for personnel consuming 15L/day is suggested to be Marginal, in part because this is a TB MED 577 standard which was developed using less conservative interpretations of toxicity information that other MEGs. The Marginal category is associated with personnel with mild effects and a few developing more significant effects that begin to impair functional abilities. According to the additional information summarized above, you feel confident that at 4 mg/L, the effects caused by cyanide would not be noticeable to personnel and, therefore, would *not* be expected to degrade performance capabilities or impact the mission. In addition, there are no long-term or delayed effects associated with the hazard. So a Marginal severity seems overly conservative. But you do note that the sampling was limited and that there is a possibility that concentrations could at times be greater than 4 mg/L. Since even short-term consumption at levels of around 8 mg/L could cause significant (performance-degrading effects), you decide to conservatively categorize the hazard severity as MARGINAL.

Step 2.2. Hazard Probability Evaluation

Without continuous monitoring, there is no way to know if the cyanide levels will fluctuate over time or what the magnitude of the fluctuations would be. Since there is only one source of drinking water available, you assume all deployed military personnel will be exposed to cyanide. You also still think it

is reasonable to assume that most personnel will be conducting activities resulting in consumption rates greater than 5 L/day, so use of the 15 L/day MEG is an appropriate reference.

Based on the Chemical Hazard Probability Ranking Chart in Table F-3, you categorize the probability of personnel exposure above the 15 L/day MEG to cyanide in drinking water as FREQUENT (i.e., you assume greater than 75% of unit will be exposed at these levels and consume water at this rate, especially for durations for as little as 5 days).

Step 2.3. Risk Characterization

Table 2-C provides the risk characterization summary.

2.3.1. Risk Estimate

Based on your classification of the cyanide hazard severity and probability, you determine the overall risk level by using the Risk Assessment Matrix in Table F-4. Based on the hazard probability and severity rankings, the overall Risk Level is HIGH. In addition to the Risk Level, you must qualify how confident you are with this characterization and the associated mission impact, including a final classification of the overall type of Threat presented by this hazard.

2.3.2. Confidence Level

There are significant uncertainties associated with this risk estimate due to the lack of complete sampling data and information available. Sources of uncertainty in this case study include:

- Reliability of sampling results/potential variability of concentrations over time,
- uncertainties associated with toxicity information for cyanide
- estimates of personnel exposures and activities, and
- estimates of health effects resulting from personnel exposures.

The lack of additional and accurate sampling for cyanide in the municipal water supply contributes most heavily of these uncertainties and as a result the overall confidence in the risk level estimate is LOW.

2.3.3. Threat Category

The presence of cyanide in the selected drinking water supply source presents a HIGH operational risk which, according to FM 100-14, corresponds to an amber unit status and is expected to significantly degrade mission capabilities if the hazards occur during the mission. This assessment is given low confidence however, with error directed and being conservatively safe/protective of personnel health. Specifically, since only non-clinical health effects are expected at the detected cyanide level, degradation of personnel capabilities is not likely. However, the data indicate that levels do exceed an actual TB MED 577 standard that - according to doctrine - cannot be exceeded. In addition, since cyanide has the potential to render unit combat or mission ineffective if concentrations increase even slightly (and since you don't have enough data to suggest that this is not the case) you consider the threat category as a HEALTH THREAT with potential to be a MEDICAL THREAT.

3. DEVELOP AND COMPARE CONTROLS FOR COA DEVELOPMENT

Step 3.1. Hazard Controls

You note that cyanide cannot be removed from water by Army ROWPU technology. So, given the potential level of risk, you determine that, if possible, an alternative source of drinking water should be

sought. If this is not feasible, the current source should be continuously/frequently monitored to ensure levels are maintained or diminished. This can be easily done with test strips. In addition, since your assessment was conducted very early on in the peacekeeping operation, it is advised that samples be sent offsite to the lab for a more thorough analysis.

Other control options include considering a protected water supply, such as a new well drilled by the Corps of Engineers and dedicated to your planned base camp, with well water treated by appropriate technology, or obtaining supplied bottled water. A final option is to investigate the potential sources of contamination to better predict fluctuations in concentrations and possibly terminating any ongoing contamination. In addition to monitoring, the municipal water supply should be guarded to ensure that intentional contamination of the source does not occur.

Step 3.2. Residual Risk

Obtaining a new water source (e.g., certified bottled drinking water) would effectively take care of the identified hazard and eliminate associated risk. Alternatively, with continuous monitoring of the municipal water supply and investigation of potential cyanide sources, fluctuations in cyanide concentrations can be determined. If this additional data indicate that cyanide levels decrease to average levels below 2 mg/L, the threat would either be eliminated (NO THREAT) or at least reduced to a NEGLIGIBLE severity, resulting in a LOW risk. However, if monitoring indicates that concentrations increase to a level greater than 8 mg/L, the overall risk level of HIGH would be confirmed with greater confidence or possibly increase to EXTREMELY HIGH. At levels greater than 8 mg/L the effects to personnel would increase and overall unit mission capability would be significantly diminished to the point of being combat ineffective.

Step 3.3. Actions to Increase Confidence in Risk Estimate

Continuous monitoring will improve estimates of fluctuations of cyanide concentrations in the water supply. In addition, identifying the source(s) of contamination will aid in this determination. Better estimation of concentrations will result in more accurate assessments of personnel exposures and increase the confidence level to MEDIUM.

TABLE 2-C. CYANIDE IN DRINKING WATER: RISK ASSESSMENT SUMMARY AND RECOMMENDED CONTROLS

CHEMICAL HAZARD	HAZARD RANKING			OPERATIONAL RISK ESTIMATE		PREDICTED HEALTH OUTCOME		CONTROLS & NOTES
	HAZARD TYPE	HAZARD PROBABILITY	HAZARD SEVERITY	RISK LEVEL	CONFIDENCE	DURING DEPLOYMENT	AFTER DEPLOYMENT	
Cyanide in drinking water with consumption rates at 15 L per day	Health Threat, potential Medical Threat	Frequent	Marginal	High	Low	Symptoms: No clinical symptoms to possible headache, breathlessness, weakness, palpitation, nausea, and others Incidence: ~10%	Symptoms: uncertain Incidence:	Alternate drinking water source and/or additional analysis of water

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CS-3 Peacekeeping Site Reconnaissance

MISSION AND ENVIRONMENTAL SETTING

You are deployed on a peacekeeping mission near the southern tip of South America. You accompany an infantry company that will be performing a border reconnaissance/security mission. It is undetermined at this time how long the mission will last, although approximately 2 weeks is anticipated. A temporary base camp must be established for the reconnaissance team. "Site X" is determined to be a particularly ideal location. Part of the mission is to evaluate its suitability as a more permanent base camp for future activities that could last up to one year in duration.

Your preventive medicine responsibilities require you to assess the potential health threats to the military personnel from environmental chemicals that may be present at Site X. The team is carrying limited supplies in order to maneuver quickly. This includes three days of drinking water.

Your task is twofold:

1. Assess the OEH hazards posed to the members of the reconnaissance mission.
2. Assess and determine health threats to other personnel who may eventually be sent to the area for long-term (base-camp) deployment status.

The commanding officer will balance health risks with other risks such as logistical obstacles and physical hazards in order to make appropriate operational decisions regarding the reconnaissance mission, as well as for future deployments into the area.

PART A - INITIAL RISK ASSESSMENT

A-1. HAZARD IDENTIFICATION

Step A-1.1. METT-TC: Chemicals, Media, and Locations

You consider all general information immediately available. Site X is five acres in size and is near a small town. There are some indications of industrial activity including two abandoned structures. You notice a slight aromatic odor around the side of one structure. A municipal water supply is identified in one of the structures; however, a member of the reconnaissance team tasted the water and noted that it had a slight fuel-like taste, although there is no odor.

Note: Tasting of water sources without knowing that they are safe is NOT recommended. However, individuals ignorant of this rule of thumb are sometimes known to taste untested water. If this happens, that information can be useful. Such "sampling" of water sources should be avoided.

Using the kits in your Water Quality Analysis Set-Preventive Medicine (WQAS-PM), you check the identified water supply in accordance with TB MED 577 (*Sanitary Control and Surveillance of Field Water Supplies*). You determine that the physical and chemical properties measurable by the kits in your WQAS-PM meet the Tri-Service Standards listed in the Appendices of TB MED 577. Because of the

strange taste in the water, you collect three grab samples around noon on the first day. The water samples are sent to the supporting medical laboratory for rear-area analysis. The results may not be available for up to seven days.

Later in the afternoon, you obtain three, 1-hour air samples from around the site, locating two samples nearby the two structures in the camp and one sample in the middle of the camp away from the structures. You analyze them using your available field equipment.

No obvious spills are observed, so no surface soil samples are collected.

Step A-1.2. Preliminary Threat Analysis

(A) Water Hazards
The first reaction may be that since the water meets the Tri-Service Standards, there may be no direct Health Threats associated with drinking from the available water source. However, you note that the field kits do not provide a complete analysis, so the results of rear-area analysis may determine that the fuel-like taste may be from other contaminants not detected by your WQAS-PM kit that may pose health threats. In addition, due to the fuel-like taste personnel may drink less than optimum amounts of water, resulting in a dehydration hazard. You decide to inform your commander of the potential HEALTH THREAT. The commander decides that there is enough concern to warrant the acquisition of additional bottled water to be sent to the field team for the duration of the reconnaissance mission. Decisions regarding potential future use of the water source will be deferred pending receipt of rear-area results.

(B) Airborne Hazards
The air screening analysis identified the following compounds at the concentrations shown in Table 3-A along with the corresponding Air-MEGs.

TABLE 3-A. AIR DATA AND ASSOCIATED AIR-MEG VALUES

Chemical Detected	Site Air Concentrations (mg/m^3) *			Air-MEG Values (mg/m^3)			
	A Structure	B Structure	C Site center	1-hour (minimal)	8-hour	14-day	1-year
Acrylonitrile	0.01	0.02	0.01	22	4.4	0.22	0.11
Aldrin	0.21	0.20	0.009	25 **	0.25 [S]	0.006 [S]	0.00098 [S]
Benzene	202	32.0	2.0	160	1.6	0.16	0.039 [S]

* Data represent 1-hour averaging times.
** Value is the severe effect level because TG 230 provides no value for the 1-hour minimal and significant effect levels.
[S] Skin notation, dermal exposures have the potential for significant contribution to overall dose.

In addition to noting the MEG values, you check the type of health effects posed by acrylonitrile, aldrin, and benzene – and note that they all cause similar irritating and CNS effects and are classified as (Level

A-B) carcinogens. You decide to evaluate each chemical hazard separately first, but realize that multiple chemical hazards (particularly when they affect similar target organs/systems) may compound the overall health risk.

At a glance, you note that while acryonitrile was detected at each location, the concentrations were all below the MEGs, including the 1-year MEG. Therefore, you decide that the hazard from acryonitrile *alone* does not pose a health threat.

You now focus on the hazards presented by the other two chemicals, which have been detected above some of the associated MEGs. The following demonstrates your preliminary analysis of the threat posed by these air contaminants:

?? Aldrin: All concentrations are greater than the 14-day and 1-year MEGs, indicating that aldrin poses a potential HEALTH THREAT (though probably not a Medical Threat) to the reconnaissance team as well as for personnel in a future long-term base camp.

?? Benzene: Since all of the concentrations are greater than the 14-day and 1-year MEG, there may be some adverse health impacts associated with exposure to benzene at this site, and thus this presents a HEALTH THREAT. More importantly, one of the samples detected benzene at a 1-hour average concentration (202 mg/m^3) that is greater than the 1-hour minimal effects Air-MEG (160 mg/m^3), though it is less than the significant effects Air-MEG (479 mg/m^3). This could result in a MEDICAL THREAT in that noticeable effects may begin and a few personnel may experience some impairment/degradation of functional abilities.

You conclude that the benzene and aldrin together with the acrylonitrile are an airborne hazard that present a HEALTH THREAT (many personnel can be expected to have some irritation/discomfort, and there is potential for increased cancer risk) with potential to be a MEDICAL THREAT (irritation may become more severe along with headaches, nausea that could impair some personnel ability to function at 100% capability). You also note that the two samples nearest the structures (A and B) yield the highest concentrations and, thus, the vicinity around the structures appears to pose somewhat higher risk.

Since the greater threat is near the structures that are located to the east side of the site, you recommend to the commander that personnel locate activities upwind (north west) of the area. The commander agrees since the structures are not located in a critical area of the site and can be easily avoided. As a precaution, you post some warning flags near these areas.

A-2. HAZARD ASSESSMENT

Since your commander has instituted the controls necessary to eliminate one hazard to the reconnaissance team by acquiring bottled water for the duration of their mission and has mitigated an aspect of the airborne hazard, you focus on a more detailed assessment of the degree of risk posed to the recon and long-term personnel from airborne exposures around the central area of the site. Once you obtain the water analysis results you will re-assess the overall risk to long-term deployment personnel.

You begin your air hazard assessment by focusing on the primary hazards aldrin and benzene, although you keep in mind that the presence of acrylonitrile contributes to the hazard.

Step A-2.1. Hazard Severity Evaluation

You begin by re-evaluating the concentrations from Sample C and comparing to associated MEGs (see Table 3-B).

TABLE 3-B. RE-EVALUATION OF THREAT SEVERITY

Chemical	Concentration (from central area)	Air-MEG Values (mg/m^3)			
		1-hour (minimal)	8-hour	14-day	1-year
Aldrin	0.009 mg/m^3	25 **	0.25 [S]	0.006 [S]	0.00098 [S]
Benzene	2.0 mg/m^3	160	1.6	0.16	0.039 [S]

* Data represent 1-hour averaging times.
** Value is the severe effect level because TG 230 provides no value for the 1-hour minimal and significant effect levels.
[S] Skin notation, dermal exposures have the potential for significant contribution to overall dose.

(A) Aldrin
The concentration exceeds the 1-year MEG, but more importantly it exceeds the 14-day MEG. From the tables in Appendix C of TG 230, you note the types of symptoms caused by inhalation exposures to Aldrin above the 14-day MEG include the following, in order of increasing severity:

- Headache, dizziness
- Nausea, vomiting, malaise
- Limb jerks, convulsions
- Coma, hematuria (blood in urine), azotemia (excess of urea in blood due to kidney failure)

The 14-day MEG is defined as the airborne concentration for a continuous exposure for up to 14 days (24 hours/day) that should not impair performance and is considered protective against any significant, non-cancer effects. If soldiers experience aldrin exposures greater than the 14-day MEG, then performance degradation could result, or the potential for inducing delayed/permanent disease (e.g., kidney disease or cancer) increases.

You estimate that true exposures for individuals exceeding the MEG will only be slightly greater than the MEG. Therefore, the more serious symptoms listed above are not likely to occur. The most likely symptoms would be headache, dizziness, nausea, vomiting, and malaise. Based on the severity-ranking chart in Table F-2, these would be defined as "mild illness or temporary irritation" in a small portion (0-10%) of the exposed group. A hazard severity ranking of NEGLIGIBLE would, therefore, be indicated.

(B) Benzene
As with aldrin, the 1-year MEG is exceeded, but of greater importance in this case is that the 14-day and even 8-hour MEGs are exceeded. The types of symptoms caused by inhalation exposures to benzene above the 8-hour and 14-day MEG include the following in order of increasing severity:

- Eye, skin, nose, and respiratory irritation, headache

- ?? Nausea, loss of coordination, fatigue, lack of appetite, weakness, exhaustion, dermatitis
- ?? Bone marrow depression, cancer

If soldiers experience benzene exposures just greater than the 14-day MEG, then performance degradation could result, or the potential for inducing delayed/permanent disease (e.g., kidney disease or cancer) increases. If soldiers experience benzene exposures greater than the 8-hour MEG, then exposures could begin to produce mild, non-disabling, transient, reversible effects, if any. Such effects should not impair performance unless exposure concentrations begin to increase more, where performance degradation could result, especially for tasks requiring extreme mental/visual acuity or physical dexterity/strength.

You estimate that true exposures for individuals exceeding the 8-hour MEG will only be slightly greater than the MEG. Therefore, the more serious symptoms listed above are not expected to occur. The most likely symptoms would be headache, dizziness, nausea, vomiting, and malaise. Based on the severity-ranking chart in Table F-2, these would be defined as "mild illness or temporary irritation" in a small portion (0-10%) of the exposed group. A hazard severity ranking of NEGLIGIBLE would, therefore, be indicated.

(C) Multiple Chemical Interactions: You note the possible increase in type/severity of effects due to the combined effects of the mixture. Specifically, the presence of acrylonitrile and aldrin with benzene might increase the severity of skin irritation and increase risks of cancer. The true effects/severity of such a mixture are not known, however.

Step A-2.2. Hazard Probability Evaluation

The portion of the unit that may actually experience exposures greater than the 8-hour or 14-day MEG is a large unknown. You assume that all personnel (during both the reconnaissance mission as well as during long-term deployment at the base-camp) will be exposed to the air mixture of aldrin, benzene, and acrylonitrile each day. However, since personnel will be rotating duties for camp maintenance, meals, training and security duties, most personnel will be away from the camp regularly. Exposures to the chemical mixture will be somewhat intermittent during the deployment (both reconnaissance as well as base camp – although base-camp deployment will result in more consistent exposures).

(A) Aldrin

Reconnaissance Mission:
The 1-hour average concentration of aldrin at the site center was 0.009 mg/m^3, while the 14-day MEG is 0.006 mg/m^3. Due to the knowledge about the activity patterns of recon personnel over the course of their operation, you estimate that most reconnaissance personnel will not experience 14-day (24 hour/day) average exposures above the 14-day MEG of 0.006 mg/m^3. You therefore rank the aldrin hazard probability for the reconnaissance mission as OCCASIONAL, as remotely possible that personnel will experience exposures greater than 0.006 mg/m^3.

Base-Camp (long-term exposure):
For personnel stationed at a base-camp you also assess the probability that the 1-year (24-hr daily average) guideline will be exceeded. In this case, you think it is very possible that most personnel will be exposed to average daily concentrations through a year's time above the 1-year air MEG of 0.00098 mg/m^3. Therefore, you rank the probability of this long-term deployment hazard as FREQUENT.

(B) Benzene

The 1-hour average concentration of benzene at the site center was 2.0 mg/m^3, a concentration greater than the 1-year, 14-day MEG (0.16 mg/m^3) and the 8-hour MEG (1.6 mg/m^3). However, the concentration was much less than the 1-hour minimal-effect MEG of 160 mg/m^3. You focus your assessment on the most immediate hazard (shorter of the two exposure durations of concern (8-hrs)).

You estimate that most if not all personnel that remain at the camp during any given day (either during reconnaissance mission or long – term deployment at the base camp) will experience 8-hour average exposures greater than the 8-hour MEG. You therefore rank the benzene hazard probability for either deployment scenario as FREQUENT.

Step A-2.3. Risk Characterization

Table 3-C provides the risk characterization summary.

2.3.1. Risk Estimate

The above hazard rankings combine to present an overall operational risk of MODERATE. This risk level forecasts a unit status of Amber (Mission Capable, with minor deficiencies), if the Command bases its decision framework on FM 101-5-1.

2.3.2. Confidence Level

You consider your confidence in both of these risk estimates to be LOW. This is based, primarily on the following limitation of the assessment. Though the measured air concentration data are considered good because the field measurement equipment is fairly accurate, the number of samples is too small to provide a confident representation of true air concentrations over the course of a day and over the course of the two-week mission.

2.3.3. Threat Category

You determine that these airborne hazards pose a HEALTH THREAT, but not a Medical Threat to both the reconnaissance team as well as personnel stationed at the base camp.

A-3. DEVELOP AND COMPARE CONTROLS FOR COA DEVELOPMENT: RECON

Step A-3.1. Develop Controls

You discuss control action options that could reduce the overall MODERATE risk with the unit commander. These options include:

1. Accept the risk and remain at Site X, but monitor for symptoms consistent with benzene exposures. If effects emerge in the unit to unacceptable levels, then the commander will re-evaluate the situation.
2. Accept the risk temporarily and perform a risk re-assessment after another day with additional air data. You would continue air sampling to cover more of the site and several times in the day.
3. Relocate the personnel to an alternative camp.

(A) Reconnaissance Mission:
Because only the airborne exposures were of concern to the RECON mission and the risk level is Moderate, the need for controls is not deemed critical. The commander decides to accept the risks (chooses Option 1) posed during this short-term mission. He asks you to prepare a short briefing to notify personnel as well as medical staff and to ensure that the situation along with any identified health outcomes that could be associated with such exposures are properly documented.

(B) Base Camp (Long-Term) Deployment:
Pending the water analysis, you hold off determining control actions at this time.

Step A-3.2. Residual Risks
Since Option 1 was selected for the RECON mission, the residual risk would remain MODERATE.

Step A-3.3. Actions to Increase Confidence in Risk Estimate
In this case, the additional sampling (Option 2) would increase the overall confidence in you risk characterization.

PART B - RE-ASSESSMENT OF RISK

B-2. HAZARD ASSESSMENT

Thus far you have identified an airborne health threat of Moderate risk to personnel who may be sent to Site X for long-term deployment status. At this time, the results from the rear-area water analyses have arrived. You now need to consider how the hazards combined from air and water may contribute to overall Risk.

Data indicate that one chemical - benzene - was present in the water at an average concentration of 0.9 mg/L, with little variability in concentration. This is consistent with the taste threshold range of 0.5- 4.5 mg/L indicated in the TG 230 Table in Appendix D. You have determined that the MEGs for the 5 L/day consumption rate are most appropriate for this assessment because of the climate in this area of the world (i.e., southern tip of South America).

Step B-2.1. Hazard Severity Evaluation
The health effects of concern for benzene in water are vomiting, lightheadedness, headache, anemia and other effects. Longer-term effects include immuno-suppression, bone marrow suppression, and cancer, similar to the effects of air exposures. Since all the MEGs are designed represent a protective level for these effects, concentrations exceeding the MEGs indicate the potential for these effects to occur. The operational severity of health effects (including number of personnel affected) that may occur during the deployment cannot be directly estimated. While a strict interpretation of the TG 230 Suggested Severity Ranking Chart in Table F-2 indicates that the severity of an exceeding a (non-TB MED 577) Water MEG results in a NEGLIGIBLE degree of severity, you assume that since even 5 day and 14-day Water MEGs are exceeded for a situation that would involve much longer exposure, you decide to rank the severity as MARGINAL, with the possibility that the health effects amongst some personnel may be severe enough to result in performance degradation.

Step B-2.2. Hazard Probability Evaluation
You rank the benzene hazard probability in water, relative to the 1-year MEG (0.14 mg/L), as FREQUENT, because if this water source were to be used all soldiers would be exposed to such levels every day. Because the concentration is also greater than the 5 and 14-day (5 L/day) MEGs, which are both 0.3 mg/L, the hazard probability, relative to the short-term MEGs, is also FREQUENT.

Step B-2.3. Risk Characterization
Table 3-C provides the risk characterization summary.

B-2.3.1. Risk Estimate

The airborne hazards present a risk level of MODERATE, indicating a potential unit status of AMBER (Mission Capable, with minor deficiencies), if the command bases its decision framework on FM 101-5-1. The waterborne hazards present a HIGH risk, indicating a potential unit status of RED (Combat ineffective), if the Command bases its decision framework on FM 101-5-1.

B-2.3.2. Confidence Level

You consider your confidence in the risk estimates to be LOW. Though the measured air and water concentration data are considered good, the number of samples is too small to provide a confident representation of true air and water concentrations over the course of the course of the future deployment.

B-2.3.3. Threat Category

Your previous judgment that these airborne hazards pose a HEALTH THREAT, rather than a medical threat, should not change. The consumption of water from the supply at the site, poses a MEDICAL THREAT because of the potential for health effects that may degrade functional abilities of personnel.

B-3. DEVELOP AND COMPARE CONTROLS FOR COA DEVELOPMENT

Step B-3.1. Hazard Controls

Because the airborne hazards pose the same MODERATE risk level and additional data have not been collected, the same controls and residual risks identified for the reconnaissance team apply. After checking in Appendix G of TG 230 (Water Quality Information Paper IP-31-014), you determine that Reverse Osmosis (RO) Treatment is not generally very effective against industrial organics. Therefore you may not significantly reduce the benzene levels with a RO unit. As such, the only viable control action against this hazard would be to procure bottled water for consumption.

Step B-3.2. Residual Risks

Use of bottled water would eliminate the hazard. However, based on recent findings you have learned that certain in country bottled water batches have not been of acceptable standards – so some additional assessment of such a source would be advised.

Step B-3.3. Actions to Increase Confidence in Risk Estimate

Again, additional sampling to better characterize the ambient air and water supply could be recommended.

TABLE 3-C: AIR AND WATER RISK ASSESSMENT SUMMARY AND RECOMMENDED CONTROLS

CHEMICAL HAZARD	HAZARD RANKING			OPERATIONAL RISK ESTIMATE		PREDICTED HEALTH OUTCOME		CONTROLS & NOTES
	HAZARD TYPE	HAZARD PROBABILITY	HAZARD SEVERITY	RISK LEVEL	CONFIDENCE	DURING DEPLOYMENT	AFTER DEPLOYMENT	
Air	Health Threat	Frequent	Negligible	Moderate	Low	Symptoms: mild temporary respiratory/eye/ skin irritation, headache, nausea, malaise Incidence: <10%	Symptoms: increased cancer and leukemia risk; kidney disease Incidence: <10%	Modify activity patterns, PPE, increase awareness, develop contingency plan
Water	Potential Medical Threat	Frequent	Marginal	High	Low	Symptoms: temporary vomiting, lightheadedness, headache, anemia Incidence: <10%	Symptoms: Increased risk of immuno-suppression, bone marrow suppression, and cancer Incidence: <10%	Eliminate hazard – obtain alternate drinking water source (such as bottled water).

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CS-4 Drinking Water: Chemical Exposure and Dehydration

MISSION AND ENVIRONMENTAL SETTING

An early insertion team will carry hand-held water treatment devices into their phase of a deployment. They intend to use local surface waters as a source of drinking water for several weeks. The environment is temperate, but due to the expected exertion level, consumption rates of up to 15 L/day are expected.

1. HAZARD IDENTIFICATION

Step 1.1. METT-TC: Chemicals, Media, and Locations

You learn that the local surface waters intended for use are brackish and have chloride concentrations around 1200 mg/L. The planner for the early insertion operation wants to know if that will be a problem for his troops.

Step 1.2. Preliminary Threat Analysis

You refer to Appendix D. The Water-MEG for chloride indicates that deployed personnel can drink water every day with chloride concentrations up to 600 mg/L in any climate for up to two weeks. However, at this concentration, according to the notes in Appendix D, about 2% of personnel might refuse to drink the water based on poor taste and are at an increased risk of dehydration. At a concentration of 1000 mg/L it is estimated that 10% of personnel are at risk of dehydration. You know that chlorides produce a salty or metallic flavor in water that becomes greater with increasing chloride concentrations. You also note that the Water-MEG is followed by a single asterisk indicating that the guideline is from the Tri-Service Field Drinking Water Standards (TB MED 577). Since the detected concentrations are twice this level, chloride is considered a MEDICAL THREAT and is evaluated further.

2. HAZARD ASSESSMENT

Step 2.1. Hazard Severity Evaluation

You get more details by referring to the TB MED 577. The major health effect of concern resulting from chloride exposure is dehydration. Dehydration symptoms can include weariness, apathy, impaired coordination, delirium, and heat stroke. At the Tri-Service Standard of 600 mg/L, about 2% of deployed military personnel can be expected to decline to drink the water and to be at risk of dehydration. As chloride concentrations reach 900 mg/L, approximately 7% of the deployed force might refuse to drink the water and become susceptible to dehydration. At chloride concentrations around 1200 mg/L, about 18% of the deployed force might refuse to drink the water and become susceptible to dehydration. At chloride concentrations around 1500 mg/L, about 36% of the deployed force might refuse to drink the water. In addition, at concentrations above the TB MED standard, there is increasing risk that non-acclimated deployed military personnel might initially experience laxative effects. Since the surface waters contain 1200 mg/L of chloride, approximately 18% of the unit may resist drinking the water and will be susceptible to dehydration. Table 4-A summarizes the estimated impact of dehydration on personnel from increasing chloride concentrations in drinking water.

TABLE 4-A. ESTIMATED IMPACT OF DEHYDRATION ON MILITARY PERSONNEL WITH INCREASING CHLORIDE CONCENTRATIONS IN DRINKING WATER*

Chloride Concentration in Drinking Water (mg/L)	Estimated % of Personnel at Risk of Dehydration
0	0.1
300	0.5
600	2.1
900	6.9
1200	18
1500	36

* These estimated impacts of dehydration apply to any consumption rate

You refer to the Chemical Hazard Severity Ranking Chart in Table F-2 to determine the hazard severity posed by personnel exposure to 1200 mg/L of chloride in the drinking water. You note that approximately 18% of the unit is predicted to exhibit symptoms of dehydration. Dehydration can be considered a health effect ranging from mild illness and irritation to one that impairs functional abilities. The symptoms are expected to occur during the mission. In addition, some personnel may suffer from laxative effects or combined effects from heat stress. Therefore, the resulting hazard severity using this chart is classified as MARGINAL to CRITICAL.

Step 2.2. Hazard Probability Evaluation

Since the treated surface water will be the only source of drinking water, 100% of the unit will be exposed to chloride in the water. Estimated chloride concentrations are greater than the Water-MEG so it is also expected that 100% of the unit will be exposed to chloride levels greater than the guidance. By using the Chemical Hazard Probability Ranking Chart in Table F-3, the hazard probability should be considered FREQUENT.

Step 2.3. Risk Characterization

Table 4-B summarizes the risk characterization.

2.3.1. Risk Estimate

As indicated above, at 1200 mg/L of chloride, as much as 18% of the early insertion team may decline to drink the surface water because of poor taste. Those team members who find the taste too objectionable will probably begin to dehydrate if another source of fluid is not readily available. As their dehydration increases, their ability to perform will be at increasing risk of deterioration. The risk of heat stroke also increases, especially if the early insertion team has a high workload and team members are carrying heavy loads.

Using this information and your professional judgment regarding your situation, you consult with the Risk Assessment Matrix in Table F-4 to determine the overall risk posed by exposure to chloride in drinking water. Based on the hazard ranks in the previous two sections, the corresponding operational risk estimate is considered HIGH to EXTREMELY HIGH. According to FM 100-14, the defined

consequence for these risk levels is significant degradation of mission capabilities with unit at 50-69% strength or loss of ability to accomplish the mission with unit strength below 50%.

2.3.2. Confidence Level

The confidence in the overall risk estimate for personnel exposures to chloride in drinking water is categorized as MEDIUM based on applying the Risk Assessment Matrix in Table F-4. Although detailed information is lacking regarding true personnel activity patterns, water consumption was already assumed to be at a maximum consumption rate to represent a worst-case exposure scenario. The TB MED 577 provides well-known symptoms for dehydration and the health outcome is plausible. Uncertainties in the sampling data and estimates of concentrations limit the confidence of this risk estimate to medium. For instance, information was not provided on the sampling methods used or if other substances were sampled for in the surface waters.

2.3.3. Threat Category

Based in the hazard assessment, exposures to current estimated levels of chloride in drinking water pose an extremely high operational risk. This implies that exposures to chloride in the drinking water have the capability to render the unit ineffective and should be considered a MEDICAL THREAT to the mission.

3. DEVELOP AND COMPARE CONTROLS FOR COA DEVELOPMENT

Step 3.1. Hazard Controls

Based on the high to extremely high level of risk, you recommend to the mission planner that an alternate source of drinking water, such as bottled water, be supplied. If this is not feasible, the water consumption of every individual in the unit should be closely monitored in order to help identify individuals that may be at risk of dehydration and take action before they are seriously affected. A risk communication plan to educate personnel on the risks of dehydration prior to the mission may help to encourage personnel to consume adequate amounts of water.

Hand-held water treatment devices would not be sufficient to remove chlorides and treat the quantity of water needed for the deployment duration. A Reverse Osmosis Water Purification Unit (ROWPU) would be required to produce potable water from a brackish source. However, this is not a viable option for the early insertion team.

Step 3.2. Residual Risk

Providing an alternate source of water would alleviate the potential risk altogether. If the brackish surface water is used for drinking, careful monitoring and educating personnel on the risks of dehydration should help reduce the operational risk somewhat.

Step 3.3. Actions to Increase Confidence in Risk Estimate

Confirmation sampling of the surface water bodies for chloride and other potential contaminants would increase your confidence in the risk estimate. In addition, if the water were found to contain chloride at the levels that are expected, monitoring of personnel would provide real-time data to verify your estimate of operational risk.

TABLE 4-B. CHLORIDE IN DRINKING WATER: RISK ASSESSMENT SUMMARY AND RECOMMENDED CONTROLS

CHEMICAL HAZARD	HAZARD RANKING			OPERATIONAL RISK ESTIMATE		PREDICTED HEALTH OUTCOME		CONTROLS & NOTES
	HAZARD TYPE	HAZARD PROBABILITY	HAZARD SEVERITY	RISK LEVEL	CONFIDENCE	DURING DEPLOYMENT	AFTER DEPLOYMENT	
Chloride in Drinking Water	Medical Threat	Frequent	Marginal to Critical	High to Extremely High	Medium	Symptoms: weariness, apathy, impaired coordination, delirium, heat stroke Incidence: 18%	Symptoms: uncertain Incidence:	Alternate source of drinking water such as bottled water

CS-5 Assessing Base Camp Air Quality

MISSION AND ENVIRONMENTAL SETTING

You are assisting with setting up a temporary base camp to be used as a staging area for rotating Army National Guard (ARNG) units performing an OCONUS annual training (AT). Units will be located in this area for no more than two weeks at any one time. You notice some pollution emanating from an industrial area in the nearby city. The base camp itself is on part of an old mining facility, but there is no indication that the mining activities that occurred in the past will present any hazards to personnel deployed temporarily to the camp. In addition, intelligence reports indicate that sabotage to industrial operations in the nearby city is unlikely. The climate where the base camp is planned is categorized as temperate.

As part of your preventive medicine duties, you assist with monitoring and sampling procedures. You have been asked to obtain data on specific criteria air pollutants as is done in the U.S. to evaluate the overall quality of the air. In addition, you are assessing the potential for any adverse health effects for the personnel that are scheduled to establish the base camp and for the follow-up personnel that will use the camp. You have been instructed to limit your health effects assessment at this time to personnel with a maximum deployment of two weeks.

1. HAZARD IDENTIFICATION

Step 1.1. METT-TC: Chemicals, Media, and Locations

Only one day of air sampling was conducted for three different one-hour time periods during that day. All three of the samples were collected at the same location near the center of the base camp. Of the six criteria air pollutants sampled, only sulfur dioxide (SO_2) and particulate matter (PM_{10}) were detected. It surprises you that only SO_2 and PM_{10} were detected, because air pollution often consist of other associated pollutants. Nonetheless, you take the data that you have and move through the hazard identification process. Table 5-A presents the one-hour average concentrations for SO_2 and PM_{10}. Estimated daily average concentrations are also included on the table. You estimate daily average concentrations by assuming that each of the one-hour samples represents an equal portion of a day (8 hours). For example, you estimate the PM_{10} daily average by dividing the sum of 150 ?g/m^3, 400 ?g/m^3, and 254 ?g/m^3 by three. You recognize that you are introducing uncertainty by performing these calculations but would like to distinguish peak exposures from daily exposures.

TABLE 5-A. SAMPLE AND CALCULATED CONCENTRATIONS

	Sample 1 Time 0900-1000	Sample 2 Time 1200-1300	Sample 3 Time 2000-2100	Estimated Daily Average *
SO_2	0.4 mg/m^3	3.1 mg/m^3	0.5 mg/m^3	1.3 mg/m^3
PM_{10}	150 ?g/m^3	400 ?g/m^3	254 ?g/m^3	268 ?g/m^3

* The daily average was calculated by assuming that each individual, one-hour sample represented eight hours of the day. This assumption introduces uncertainty.

Step 1.2. Preliminary Threat Analysis

You know that after chemical hazards are detected, a judgment must be made as to the relative degree of health threat each hazard poses. The purpose is to limit the risk assessment to the hazards that pose credible health threats. The chemical hazards can be classified into health hazard categories (No Threat, Health Threat, and Medical Threat) based on a rapid comparison of a conservative estimate of the exposure point concentrations (i.e., maximum detected concentrations and/or average concentrations) to available standard military guidelines. The outcome of this step is described in the text below and shown in the Table 5-B.

For SO_2, the standard military guidelines that are available include the 1-hour Air-MEG Significant Effects Level, the 8-hour Air-MEG, and the 14-day Air-MEG. For PM_{10}, there currently are no Air-MEGs, but comparisons may be made to U.S. general population guidelines.

In order to classify the hazards, a general nature of the effects associated with exposures at, or near, the selected guideline must be known. The hazard identification is determined based on this information.

(A) SO_2

The 1-hour Air-MEG does not include a Minimal Effects Level. You note that the concentrations are less than the 1-hour Air-MEG Significant Effects Level and the 8-hour Air-MEG, but the sample taken between 1200 and 1300 has a concentration higher than the 14-day Air-MEG level. You realize that you may have "peaks" when the concentration is higher than the guideline, but on average you feel that the concentrations will be below the 14-day level. In fact, the estimated daily average concentration from the three sampling times (1.3 mg/m^3) is less than the 14-day guideline. You recognize, however, that the daily average concentration that you calculated is subject to uncertainty.

You read in the "Notes" column of Appendix C that SO_2 may have some metallic taste associated with it at certain peak concentrations. This, however, is not a particular health concern. The health effects of concern would be irritation of the mucous membranes (e.g., eyes, throat) as well as coughing and choking. Given that the exposure point concentration levels in Table 5A are less than guideline levels and that the health effects are mild and temporary, you categorize SO_2 as NO THREAT, and you do not evaluate it further in the next step of the risk assessment.

(B) PM_{10}

Though there are no short-term Air-MEGs for PM_{10}, you refer to Appendix C Tables C-4 and C-5 to compare with U.S. general population guidelines. You note that the peak concentration from the sample taken between 1200 and 1300 is in the range for Level 2 of the U.S. General Population Index Criteria for Particulate Matter. Concentrations in this range may cause significant increases in respiratory symptoms, such as coughing, mucous and aggravation of lung disease (e.g., asthma). People with lung disease should avoid outdoors; others should minimize moderate to heavy exertion. The estimated daily average concentration from the three sampling times (268 ? g/m^3) is in the range for Level 1. Again, concentrations in this range may increase respiratory symptoms; people with lung disease should restrict heavy exertion and others should minimize prolonged exertion. Because the daily average concentration of PM_{10} is higher than the general population level, you determine that the PM_{10} exposure may pose a HEALTH THREAT to personnel exposed for 1-14 days. Therefore, you proceed to the next step of the risk assessment.

(C) Mixture of SO_2 and PM_{10}
You note that both SO_2 and PM_{10} exhibit similar health effects, and therefore, that SO_2 may exacerbate the potential effects of PM_{10}. You note that this interaction cannot be quantified, but it should be considered in the overall assessment of the conditions at the base camp.

TABLE 5-B. PRELIMINARY THREAT ANALYSIS FOR AMBIENT AIR

Hazard	Exposure Point Concentration	Standard Guideline		Hazard Classification	Rationale †
		Value	Type		
SO_2	3.1 mg/m^3 (peak concentration)	8 mg/m^3	1-hour Air-MEG Significant Effects Level	No Threat	Exposure point concentration is less than the 1-hour standard guideline for significant health effects
SO_2	3.1 mg/m^3 (assuming 1-hour concentration represents concentration for 8 hours)	5 mg/m^3	8-hour Air-MEG	No Threat	Exposure point concentration is less than the 8-hour standard guideline minimal to non-significant health effects
SO_2	1.3 mg/m^3 (estimated daily average concentration)	2.6 mg/m^3	14-day Air-MEG	No Threat	Exposure point concentration is less than the 1-day standard guideline for minimal to non-significant health effects
PM_{10}	400 ?g/m^3 (peak concentration)	255 – 354 (1) 355 – 424 (2) 425 – 604 (3)	USEPA civilian guidelines ‡	Health Threat	Exposure point concentration is in the range for significant increase in respiratory symptoms
PM_{10}	268 ?g/m^3 (estimated daily average concentration)	255 – 354 (1) 355 – 424 (2) 425 – 604 (3)	USEPA civilian guidelines ‡	Health Threat	Exposure point concentration is in the range for increased respiratory symptoms

†: Additional detail is provided in the text above.
‡: Provided in the TG. The meaning is a modification from the USEPA guidance.
(1) Increased respiratory symptoms. For example, coughing and aggravation of lung disease (e.g., asthma). People with lung disease should restrict heavy exertion; others should minimize prolonged exertion.
(2) Significant increase in respiratory symptoms. For example, coughing, mucous and aggravation of lung disease. People with lung disease should avoid outdoors; others should minimize moderate to heavy exertion.

(3) Serious risk of respiratory symptoms. For example, coughing, mucous, shortness of breath and aggravation of lung disease. All should minimize outdoor exertion.

2. HAZARD ASSESSMENT

Step 2.1. Hazard Severity Evaluation

As stated previously, the types of symptoms caused by exposures to particulate matter include coughing, mucous, shortness of breath and aggravation of lung disease. You determine that these health effects, however, should be limited to mild illness and temporary irritation. You therefore assume that the proportion of personnel responding (i.e., the attack rate) will be few (<10%), which indicates a hazard severity level of NEGLIGIBLE from the Hazard Severity Chart in Table F-2. You note, however, that for asthmatics, the hazard severity may possibly be MARGINAL, but you do remember that Section 4.5 states that the severity of Level 1 is comparable to a minimal effects level and that Levels 2 and 3 are somewhat less severe than significant and severe effects levels.

Step 2.2. Hazard Probability Evaluation

The range of concentrations of PM_{10} is 150 – 400 ?g/m^3 with a peak during the middle of the day. The duration of the concentration peak is not known, so the average daily exposure point concentration presented is highly uncertain, as are the daily ambient air concentrations expected over the course of each two-week deployment to the base camp.

?? Portion of Unit Exposed: Based on the lack of exposure or mission information, you assume that 100% of the field unit will be exposed to PM_{10} every day for the base camp establishment deployment and for the subsequent two-week deployments.

?? Portion of Unit Exposed to Levels Higher than Guidelines: The data collected during the one day of sampling indicate that the field unit may experience PM_{10} exposures that are higher than the U.S. General Population Index Criteria for some portion of the day or as much as most of the day. Given the anticipated fluctuations in concentrations and the possible exacerbating effects from SO_2, you use your professional judgment and assume that most of the unit (>75%) will be exposed to levels higher than the guidelines.

From this information, you use the Hazard Probability Chart from Table F-3 to determine the probability for a two-week deployment. The hazard probability for PM_{10} exposure is categorized as FREQUENT.

Step 2.3. Risk Characterization

Table 5-C summarizes the risk characterization.

Step 2.3.1. Risk Estimate

With the hazard probability and hazard severity, you use the Risk Assessment Matrix in Table F-4 to determine the impact to field units with two-week deployments to the base camp. Based on the hazard rankings the resulting risk estimate is MODERATE. Some unit personnel may experience, coughing, mucous, shortness of breath and aggravation of lung disease (especially asthmatic individuals). This corresponds to an Amber Unit Status (Mission Capable, with minor deficiencies), where the unit is estimated to be at 70 – 84% strength.

Step 2.3.2. Confidence Level

You categorize the confidence level in the risk estimate as LOW for numerous reasons. You only have three samples that were taken on the same day. In addition, to estimate daily exposure point concentrations you made assumptions that introduced uncertainty. In regards to exposure patterns and field unit attributes, you lacked any information; therefore, you took a conservative stance by assuming that the entire field unit will be exposed and most of them at levels higher than the guidelines. You also do not know the respiratory health of the field units' personnel (asthmatics or people with other lung diseases). Also, the guidelines for PM_{10} were determined for the general population rather than for deployed personnel, for durations that are not consistent with the base camp mission and at levels that are not comparable to Air-MEGs. You attempted to account for the possible exacerbating effects of SO_2 on the PM_{10} evaluation by selecting the more conservative probability and severity, but the interaction between the two substances is highly uncertain. You do believe, however, that the predicted health outcome is plausible, given that there is evidence that elevated PM_{10} concentrations have caused respiratory distress in other populations.

Step 2.3.3. Threat Category

Based on the more detailed assessment, you continue to categorize the threat to base camp field units as a HEALTH THREAT.

3. DEVELOP AND COMPARE CONTROLS FOR COA DEVELOPMENT

Step 3.1. Hazard Controls

Because the risk levels are moderate, the need for controls may not be critical, but some attempt should be made to reduce them if not cost or mission-prohibited. The range of options you can present include minimizing exposure by modifying activity patterns or eliminating/minimizing exposure by using personal protective equipment.

The use of protective equipment is not the most desirable option for several reasons. Respiratory protection may offer some control for particulate matter exposure, but it would likely result in residual risks that may be of greater severity — there are several health effects attributed to continuous use of respiratory protection and other personal protective equipment. The possibility of minimizing exposure frequency by modifying activity patterns seems to be the best option. You could recommend that work shifts be no longer than 8 hours and that work be avoided during mid-day. Some other possible control efforts could be to ensure that leaders and soldiers be aware of the hazards and that they know the symptoms of particulate matter exposure. You may also recommend establishment of a contingency plan for excessive exposures and perform pre-deployment screening to ensure that individuals with asthma or other potential respiratory conditions (chronic bronchitis) are not deployed to the base camp.

Step 3.2. Residual Risk

Based on these recommended actions the overall risk to personnel and mission will be minimized to a LOW level.

Step 3.3. Actions to Increase Confidence in Risk Estimate

Initiate environmental exposure surveillance to learn more about durations of concentration peaks, the frequency of the peaks, and the possible sources of SO_2 and PM_{10}.

TABLE 5-C. AMBIENT PARTICULATE MATTER: RISK ASSESSMENT SUMMARY AND RECOMMENDED CONTROLS

CHEMICAL HAZARD	HAZARD RANKING			OPERATIONAL RISK ESTIMATE		PREDICTED HEALTH OUTCOME		CONTROLS & NOTES
	HAZARD TYPE	HAZARD PROBABILITY	HAZARD SEVERITY	RISK LEVEL	CONFIDENCE	DURING DEPLOYMENT	AFTER DEPLOYMENT	
Particulate Matter	Health Threat	Frequent	Negligible	Moderate	Low	Symptoms: respiratory symptoms such as coughing, mucous production and aggravation of lung disease (e.g., asthma) Incidence: >10%	Symptoms: uncertain Incidence:	Modify activity patterns, PPE, increase awareness, develop contingency plan

CS-6 Selecting a Drinking Water Source

MISSION AND ENVIRONMENTAL SETTING

A viable source of drinking water is needed for a two-week operation in the Middle East. Prior to the mission, several potential sources for drinking water were identified and sampled. Using this sampling data you need to decide which drinking water source to use to supply your unit with potable water for the two-week deployment. It's a rather warm arid climate so you need to be able to supply enough water to support consumption rates up to 15 L/day.

1. HAZARD IDENTIFICATION

Step 1.1. METT-TC: Chemicals, Media, and Locations

Three potential sources for drinking water were identified prior to the deployment. There is a primary source and two alternate existing sources all of which are from surface waters. Intelligence reports indicate that the primary source may have been sabotaged with nerve agent. Three water samples were obtained from this drinking water source and sent for lab analysis to confirm this report. Anticipating the potential need for an alternate source, three samples were obtained from each of the two other existing sources and sent for lab analysis – one of which appears to be contaminated through pollution. Your results indicate the presence of nerve agent in the primary source, arsenic in the first alternate source, and benzene, chlorobenzene, and phenol in the second alternate source. All three potential drinking water sources were sampled on the same day during pre-deployment.

Step 1.2. Preliminary Threat Analysis

The sampling data obtained from the primary source are included below.

TABLE 6-A. SAMPLING RESULTS COMPARED TO MILITARY EXPOSURE GUIDELINES FOR THE PRIMARY DRINKING WATER SOURCE

Contaminant	Sample 1	Sample 2	Sample 3	5-day Water-MEG 5 L/day Consumption	5-day Water-MEG 15 L/day Consumption
Nerve Agent – VX	0.02 mg/L	0.03 mg/L	0.02 mg/L	0.015 mg/L	0.005 mg/L

These data confirm your suspicions about your primary source; residual nerve agent VX was detected. A typical initial screening would be to compare the sample results to the long-term Water-MEGs. However, you find that there are no long-term values listed for VX. Therefore, you go directly to the short-term values. There is not a 2-week Water-MEG for VX, so you refer to the 5-day values included

in Table 6-A above. You note that the detected concentrations are above the 5-day Water-MEGs for both consumption rates. You also note these MEGs are in fact TB MED 577 standards and should not be exceeded. As a result, exposures to VX require more evaluation and you classify VX in the primary drinking water source as a MEDICAL THREAT to the mission.

Next you evaluate the first alternate source. The sample results from the first alternate source are provided in Table 6-B.

TABLE 6-B. SAMPLING RESULTS COMPARED TO MILITARY EXPOSURE GUIDELINES FOR ALTERNATE DRINKING WATER SOURCE NO. 1

Contaminant	Sample 1	Sample 2	Sample 3	1-year Water-MEG 5 L/day Consumption	1-year Water-MEG 15 L/day Consumption
Arsenic	0.4 mg/L	0.3 mg/L	0.4 mg/L	0.06 mg/L	0.02 mg/L

You are surprised to find arsenic in your first alternate water source. As a preliminary screening, you compare the sampled concentrations to the 1-year Water-MEGs for arsenic. You note that the values for arsenic are TB MED 577 standards and should not be exceeded. All three of the sample concentrations are greater than the 1-year Water-MEGs indicating that further evaluation is necessary. Since arsenic levels detected are above the TB MED 577standard of 0.1 mg/L it is classified as a HEALTH THREAT and potential MEDICAL THREAT.

Finally, you evaluate the second alternate drinking water source. The sampling results from this source are included below in Table 6-C.

TABLE 6-C. SAMPLING RESULTS FOR ALTERNATE DRINKING WATER SOURCE NO. 2

Contaminant	Sample 1	Sample 2	Sample 3	2-week Water-MEG 5 L/day Consumption	2-week Water-MEG 15 L/day Consumption
Benzene	0.07 mg/L	0.3 mg/L	0.17 mg/L	0.3 mg/L	0.1 mg/L
Chlorobenzene	0.64 mg/L	1.5 mg/L	1.0 mg/L	3 mg/L	1 mg/L
Phenol	2.4 mg/L	3.2 mg/L	1.7 mg/L	8 mg/L	3 mg/L

You had predicted that the second alternate drinking water source had some contamination due to the odor. You check the long-term, 1-year Water-MEGs for your initial screening and find that only benzene

has a value listed (0.042 mg/L and 0.014 mg/L for 5L/day and 15 L/day consumption rates, respectively). The detected benzene concentrations are well above this level, so you check the short-term values for benzene along with the other detected contaminants. Since the deployment duration is 2-weeks you use the 2-week Water-MEGs which are included in Table 6-C above. You compare the sampled concentrations to the 2-week Water-MEGs for the 15 L/day consumption rate. There are some samples for each contaminant that are greater than the Water-MEG. Therefore, this source is considered HEALTH THREAT and requires further evaluation as well.

2. HAZARD ASSESSMENT

Step 2.1. Hazard Severity Evaluation

In this step you need to consider the potential health effects associated with the various contaminants detected in the different water supplies and assign a hazard severity ranking to each.

(A) Primary Source

The TB MED 577 provides information on the health effects from exposure to organophosphorus nerve agents and is summarized below in Table 6-D. Performance-degrading health effects can include abdominal cramps, vomiting, diarrhea, and headaches. The concentration of nerve agents at which death might occur from repeated ingestion of drinking water over the course of several days has not been determined but is estimated to be 0.11 mg/L.

TABLE 6-D. ESTIMATED HEALTH EFFECTS FROM INGESTION OF ORGANOPHOSPHORUS NERVE AGENTS IN DRINKING WATER

Consumption Rate	Safe Water Concentration* (mg/L)	Increasing Risk of Performance Degrading Health Effects and Mortality (mg/L)	Possibility of Respiratory Distress Requiring Resuscitation (mg/L)**
5 L/day	0 - 0.012	0.012+	0.03
15 L/day	0 - 0.004	0.004+	0.01

*Based on GD since it appears to be the most toxic nerve agent where a total dose from field water is ingested in several drinks over the course of the day for an exposure period lasting up to 7 days.
**Based on single intravenous dose of VX in human volunteers.

All samples from the primary drinking water source had concentrations that are greater than the 5-day Water-MEGs for VX and the estimated concentration for severe health effects. On the basis of the information gathered regarding exposure to VX in drinking water, you estimate the severity level associated with the primary source as CATASTROPHIC using the Chemical Hazard Severity Ranking Chart in Table F-3. You determined this by comparing the sample concentrations to the estimated health effects in Table 6-D. For exposures to concentrations at the sample levels you would expect many personnel to experience incapacitation or death during the mission. This estimation reflects your particular concern regarding the small difference between a "safe" level and a "lethal" level. This small difference (referred to as a steep dose-response curve) means that a minor fluctuation in concentration can have catastrophic effects. In addition, since the concentrations are being compared to TB MED 577 standards that do not have built in safety factors, it is likely that a high percentage of the unit will experience some degree of symptoms if exposed above the standard.

(B) Alternate Source No. 1
Since all three of the arsenic concentrations were greater than the 1-year Water-MEGs, you check the short-term MEGs (a TB MED standard). Only a 5-day value for arsenic is listed: 0.3 mg/L (5 L/day consumption) and 0.1 mg/L (15 L/day consumption).

The sampled concentrations are also greater than the 5-day Water MEGs for the 15 L/day consumption rate. The TB MED provides information on the health effects from arsenic exposure in drinking water and is summarized in Table 6-E. Symptoms of acute arsenic toxicity may include edema, nausea, vomiting, headache, and abdominal pain. Characteristic symptoms of chronic arsenic toxicity include skin effects, gastrointestinal problems, peripheral vascular disease, and neurological changes.

TABLE 6-E. HEALTH EFFECTS FROM INGESTION OF ARSENIC IN DRINKING WATER

Consumption Rate	Exposure Duration	Safe Water Concentration (mg/L)	Increasing Risk of Developing Symptoms of Toxicity (mg/L)	Increasing Risk of Lethality (mg/L)
5 L/day	$\leq$ 7 days	0 – 0.3	0.3 – 14	14+
15 L/day	$\leq$ 7 days	0 – 0.1	0.1 – 4.7	4.7+
5 L/day	$\leq$ 1 year	0 – 0.06	0.06+	--
15 L/day	$\leq$ 1 year	0 – 0.02	0.02+	--

The information available regarding arsenic exposure in drinking water indicates that the risk of developing symptoms of acute toxicity increases as the concentration increases above 0.1 mg/L. The risk of severe toxic effects and fatalities increases as concentrations rise above 4.7 mg/L. You also recall that the comparison levels for arsenic are TB MED standards that do not have built in safety factors. Since the detected concentrations are all three to four times above the level that can begin to produce an acute effect, it is likely that most of the unit will begin to experience symptoms. On the basis of this information combined with the Chemical Hazard Severity Ranking Chart in Table F-2, you estimate the severity level associated with this source as CRITICAL as many personnel may experience symptoms that impair functional abilities during the mission.

(C) Alternate Source No. 2
You go to Appendix D to obtain additional information that is summarized below in Table 6-F. The absence of a carcinogen statement for chlorobenzene and phenol implies that they are not carcinogens. In addition, the notes section for phenol indicates that phenol can react with the water supply disinfectant hypochloride to produce objectionable tastes and odors. The odor you noticed is consistent with the findings. (Note that the odor thresholds are surpassed for both chlorobenzene and phenol.)

You are concerned that all contaminants are above the short-term Water-MEG, but you realize that the information you have does not clearly indicate how severe the health effects from exposure to these concentrations might be. The Water-MEGs are exceeded for one of the three samples for chlorobenzene and phenol and for two of the three samples for benzene if the consumption rate is 15 L/day. If you average the three water samples, only the averaged benzene concentration is greater than the Water-MEG for the 15 L/day consumption rate. You do note that the level for benzene is considerably below lethal levels and that the level for phenol is considerably below that which will cause dangerous effects. You also note that two of these contaminants have potential effects on the CNS and two can cause liver and kidney damage so you consider potential additive effects. The sampled concentrations for all three

substances are less than or only slightly over the guidelines. Therefore, you anticipate that few personnel will exhibit symptoms from exposure to these chemicals and that the symptoms can be considered mild illness or temporary irritation. Using the Chemical Hazard Severity Ranking Chart Table F-2, you rank the severity of exposures to contaminants in this water source as NEGLIGIBLE.

TABLE 6-F. ADDITIONAL HEALTH INFORMATION FOR CONTAMINANTS IN ALTERNATE DRINKING WATER SOURCE NO. 2

Contaminant	Potential Symptoms	Target Organ	Odor and Taste Thresholds	Human Carcinogen
Benzene	Vomiting, loss of coordination, light-headedness, headache, and anemia are a few.	Eyes, skin, respiratory system, blood, CNS, bone marrow, immune system	Odor: 2.0 mg/L Taste: 0.5 – 4.5mg/L	Yes
Chlorobenzene	Drowsiness, dizziness, light-headedness, and muscle spasms are a few	CNS, liver, kidneys	Odor: 0.05 mg/L Taste: 0.01 – 0.02 mg/L	No
Phenol	Corrosion of the mouth, throat, and stomach, nausea, and vomiting are a few.	Liver, kidneys, cardiovascular system	Odor: 0.3 mg/L	No

Step 2.2. Hazard Probability Evaluation

Though only three samples were collected from each water source, it is assumed that the data are representative of each of the water sources. Since the water supply would be the sole source of potable water for the camp, all personnel would be exposed to the contaminants present in the water on a daily basis for the duration of the mission. For the primary and first alternate sources, since the levels of contaminants detected are significantly above the TB MED 577 standards for all samples, it is assumed that a high percentage of the unit will be exposed to levels above the standard. Therefore, based on the Chemical Hazard Probability Ranking Chart in Table F-3, the hazard probability should be considered FREQUENT. For the second alternate source, the concentrations are close to acceptable levels and are not above the appropriate guidelines in one of the three samples. Therefore, the hazard probability is somewhat lower than the other two sources since it is assumed that two-thirds of the time personnel will be exposed to levels greater than the Water-MEGs. The probability for this source is considered LIKELY based on the Chemical Hazard Probability Ranking Chart.

Step 2.3. Risk Characterization

Table 6-G presents the risk characterization summary.

2.3.1. Risk Estimate

After estimating the hazard probability and hazard severity in the previous steps, you use the Risk Assessment Matrix in Table F-4 to determine the impact to the unit during a two-week operation at the camp. Both the primary and first alternate drinking water source present an EXTREMELY HIGH operational risk based on their hazard rankings. The second alternate source presents only a LOW level of operational risk to the unit.

2.3.2. Confidence Level

Your confidence in the operational risk estimates for each of the drinking water sources is considered MEDIUM based on the information available for the assessment. You know sufficient information about the expected exposures for the unit (duration, water consumption rate, high activity level). There is sampling data available for each drinking water source that was analyzed in a laboratory (in contrast to estimates from portable water kits and test strips). Water-MEGs are available for all contaminants detected and for the duration of interest (2-week comparison MEGs) in addition to information on potential health effects. There is some uncertainty in the potential fluctuations of contaminant concentrations in the water due to not knowing the contaminant sources. This is especially true for the primary source since VX has a half-life of 50 hours in water. If the primary source was not intentionally contaminated again, concentrations of VX should continually decrease but without further intelligence and sampling information to confirm this, it was assumed the unit would be exposed to the sampled concentrations.

2.3.3. Threat Category

The last step in the risk characterization is to place each of the hazards into health threat categories. You reassess your categories from the Preliminary Threat Analysis based on the complete hazard assessment. The hazards presented by the primary and first alternate drinking water source are classified as MEDICAL THREATS because they have the potential to render the unit mission ineffective. The hazards presented by the second alternate source are considered HEALTH THREATS since they are not expected to have immediate medical impacts on the overall mission effectiveness although they may cause adverse health effects in some individuals.

3. DEVELOP AND COMPARE CONTROLS FOR COA DEVELOPMENT

Step 3.1. Hazard Controls

In conclusion, you determine that bottled water is the preferred choice, but given no immediate access to a bottled supply, interim use of the second alternate source would be the next option since this source presents only a low operational risk level.

Step 3.2. Residual Risk

If bottled water was used as a drinking water source you could ensure that the overall risk level remained low. However, you could maintain a low operational risk level while using the second alternate water source if you could ensure that concentration levels are maintained or decreased.

Step 3.3. Actions to Increase Confidence in Risk Estimate

The continued monitoring of the second alternate drinking water source recommended above will also serve to increase your confidence in the risk assessment. With additional data, you would have a better understanding of the contaminant levels in the water source, which would lead to a better estimate of operational risk.

TABLE 6-G. DRINKING WATER SOURCES: RISK ASSESSMENT SUMMARY AND RECOMMENDED CONTROLS

CHEMICAL HAZARD	HAZARD RANKING			OPERATIONAL RISK ESTIMATE		PREDICTED HEALTH OUTCOME		CONTROLS & NOTES
	HAZARD TYPE	HAZARD PROBABILITY	HAZARD SEVERITY	RISK LEVEL	CONFIDENCE	DURING DEPLOYMENT	AFTER DEPLOYMENT	
VX in Primary Source	Medical Threat	Frequent	Catastrophic	Extremely High	Medium	Symptoms: abdominal cramps, vomiting, diarrhea, headaches, respiratory distress are a few Incidence: >25%	Symptoms: uncertain Incidence:	Alternate source of drinking water such as bottled water or interim use of Alternate Source No. 2
Arsenic in Alternate Source No. 1	Medical Threat	Frequent	Critical	Extremely High	Medium	Symptoms: edema, nausea, vomiting, headache, abdominal pain Incidence: >25%	Symptoms: skin effects, gastrointestinal problems, peripheral vascular disease, neurological changes Incidence:	Alternate source of drinking water such as bottled water or interim use of Alternate Source No. 2
Benzene, Chlorobenzene and Phenol in Alternate Source No. 2	Health Threat	Likely	Negligible	Low	Medium	Symptoms: vomiting, headache, dizziness, muscle spasm are a few Incidence: 0 – 10%	Symptoms: cancer, immune system depression, liver or kidney damage for benzene Incidence:	Alternate source of drinking water such as bottled water or continuous monitoring

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CS-7 Selection of Base Camp Sites

MISSION AND ENVIRONMENTAL SETTING

You are assisting with the planning for a peacekeeping mission in Central America. Two proposed base camps have been chosen. Each site could be used as a logistics base. You have been tasked to assess the environmental health-risk level for each COA.

While many other factors will come to play in the final selection process, your commander is concerned about the potential health impacts associated with what will be a long–term (up to one year) stay for most the personnel deployed to the area. The operation will commence 90 days from today. You were allowed time to conduct a very brief, initial reconnaissance of each site. Your onsite reconnaissance results are presented below.

1. HAZARD IDENTIFICATION

Step 1.1. METT-C: Chemicals, Media, and Locations

(A) COA 1. Base Camp Raptor

Base Camp (BC) Raptor is located adjacent to a river. This is muddy, and is the probable water supply. The BC is to be used only as a bulk refueling point and DS maintenance support asset. Personnel assigned to this site will primarily include (other activities will occur at other locations):

- Security personnel (A mechanized infantry line company), who will be manning a minimal perimeter in fixed positions constructed by army engineers 2 weeks into the operation.
- DS Maintenance Personnel who will be performing maintenance in a common (unimproved) motor pool.
- Logistics Personnel who will manage and distribute all classes of supply from a tent city to be constructed by Air Force Engineers during the first 7 days of the operation.

The tent city and maintenance areas are separated by an elevated road and are about 50 meters apart. There will not be a shower point at this site so solders will have to be rotated out for showers. The current plan is to have a daily shower run where 1/3 of the base camp gets a shower (i.e., a shower every three days).

At the south end of the site, you find the remains of a concrete pad. Local civilians tell you that there used to be an above ground fuel tank at this location. The tank was hit during a recent air attack. He tells you that after the fuel tank exploded, a fire burned for about six hours. This fire spread out 60 meters in all directions. You notice a faint stained area around the pad that appears to be contaminated, and a very weak sweet smell. You decide to take air, water, and soil samples to evaluate various exposures from the site. Sampling results are summarized in Table 7-A.

TABLE 7-A. BASE CAMP RAPTOR SAMPLE RESULTS

Medium	Chemical	DF	Mean	Standard Deviation	Maximum	TG 230 Long-Term MEG
Soil (mg/kg)	Lead	8 / 8	184	103	426	2200
	Lindane	* 4 / 8	301	506	785	560
	Benzo[a]anthracene	† 3 / 8	0.78	1.3	2.14	2500
	Ethyl Benzene	**† 3 / 8**	**600**	**635**	**1066**	**230**
	Toluene	† 3 / 8	480	301	887	520
	Xylene	† 3 / 8	88	40	190	210
	Chrysene	† 3 / 8	2975	6000	4470	3100
Water (mg/L)	Lindane	1 / 1	—	—	0.03	0.2 – 0.6
	Mercury	**1 / 1**	**—**	**—**	**0.002**	**0.0003 – 0.0007**
Air ‡ (?g/m^3)	**Benzene**	**1 / 1**	**—**	**—**	**160**	**39**
	Carbon Tetrachloride	1 / 1	—	—	33	320
	Dichloroethane	1 / 1	—	—	13	180

DF: Detection frequency
* These four detects are from randomly scattered locations, i.e., that are not grouped.
† These three detects were taken from the spill area.
‡ Air samples were averaged over the 0800 – 1000 time period (2 hours).

(B) COA 2. BC Wolverine

In this COA, BC Wolverine activities would include all the activities proposed for BC Raptor and much more of the operational load including housing many of the war fighters, and their motor pools.

- ?? Administrative personnel for the larger units.
- ?? DS Maintenance Personnel who will be performing maintenance in a common (unimproved) motor pool. These personnel will rotate out every third day and perform work at a remote site that has a dedicated hardstand for maintenance.
- ?? Logistics Personnel who will manage and distribute all classes of supply from fixed facilities.
- ?? Security personnel (a light infantry battalion) who will man a minimal perimeter in permanent positions constructed by army engineers 2 weeks into the operation.

BC Wolverine is a site 10 miles north of BC Raptor – inland from the river in a shallow valley. You can see what appears to be an industrialized area further up the valley.

The site was selected for logistical reasons to include the existing abandoned warehouses present. Access roads are nearby, and you have been told that local bottled water from the nearby city would be provided. There are no surface water bodies present. You decide to take air and soil samples to evaluate various exposures from the site. Sampling results are summarized in Table 7-B.

TABLE 7-B. BASE CAMP WOLVERINE SAMPLE RESULTS

Medium	Chemical	DF	Mean	Standard Deviation	Maximum	TG 230 Long-Term Guideline
Soil (mg/kg)	Fluoranthene	3 / 11	133	88	370	42000
	Lead	11 / 11	688	1100	4200	2200
Water (mg/L)	Bottled water data is unavailable					
Air * (mg/m^3)	**Mercury**	**1 / 1**	**—**	**—**	**3.2**	**0.21**
	Carbon Tetrachloride	**1 / 1**	**—**	**—**	**0.34**	**0.32**

DF: Detection frequency
* Air samples were averaged over the 1500 – 1600 time period (1 hour).

Step 1.2. Preliminary Threat Analysis

Preliminary (health or medical) threats were identified by screening media concentrations using long term MEGs. Concentrations that were above the MEGs were initially considered health threats and were analyzed further. Those chemicals retained for further analysis are summarized in Table 7-C.

TABLE 7-C. POTENTIAL HEALTH THREATS

Base Camp	Medium	Chemical	DF	Mean	Standard Deviation	Max	1-year MEG
Raptor	Soil (mg/kg)	Ethyl Benzene	† 3 / 8	600	635	1066	230
	Water (mg/L)	Mercury	1/1	—	—	0.002	0.0003#
	Air ‡ (ug/m^3)	Benzene	1/1	—	—	160	39
Wolverine	Air * (ug/m^3)	Mercury	1/1	—	—	3.2	0.21
		Carbon Tetrachloride	1/1	—	—	0.34	0.32

DF: Detection frequency
* Air samples were averaged over 1 hour. (1500 – 1600).
† These three detects were taken from the spill area.
‡ Air samples were averaged over 2 hours. (0800 – 1000)
# Retain most conservative of the possible values (For 15 L/ Day)

(A) BC Raptor
Based on the sampling results and screening with MEGs the HEALTH THREATS for BC Raptor are ethyl benzene in soil, mercury in water and benzene in air.

(B) BC Wolverine
Based on the sampling results and screening with MEGs the HEALTH THREATS for BC Wolverine are mercury and carbon tetrachloride in air.

2. HAZARD ASSESSMENT

Step 2.1. Hazard Severity Evaluation

(A) BC Raptor

Air: The effects associated with excessive benzene exposure in air are listed in TG 230 Appendix C. Initial symptoms irritation of eyes, nose and throat and potentially followed by other respiratory symptoms. The effects you expect to see are mild injury or temporary irritation amongst a small portion (e.g. <10%) of the population. According to the Hazard Severity Ranking Chart in Table F-2, you chose a hazard severity of NEGLIGIBLE for airborne chemical hazards.

Water: The effects associated with excessive exposure to mercury in water are listed in TG 230 in Appendix D. Initial symptoms include, tremors, fatigue and other CNS effects. The effects you expect to see are mild injury or temporary irritation amongst a small portion of the exposed personnel. As a result, you chose a hazard severity of NEGLIGIBLE for chemical hazards in drinking water per suggested TG230 Severity Ranking Chart).

Soil: The effects associated with excessive exposure to ethylbenzene are listed in TG 230 in Appendix E. Initial symptoms include, headache, nausea, dizziness and other CNS effects. Based on the concentration found, the volatility only a small portion (e.g. <10%) of personnel would be expected to exhibit symptoms. The effects you expect to see are mild injury or temporary irritation. As a result, you chose a hazard severity of NEGLIGIBLE for chemical hazards from soil (per the Hazard Severity Ranking Chart in Table F-2).

(B) BC Wolverine

Soil: No health threats were identified in the soil at this location.

Water: The water supply for this site is going to be obtained as bottled water from a certified source –so no health threat is associated with this pathway.

Air: Mercury and carbon tetrachloride in air were identified as a potential health threat.

1) The effects associated with excessive exposure to mercury in air are listed in TG 230 Appendix C. Initial symptoms (expected initially amongst a small portion of personnel) include irritation to eyes and skin; chest pain, dyspnea and other respiratory effects. You categorize the effects you expect to see as mild injury or temporary irritation. Per the suggested Hazard Severity Ranking Chart, you chose a hazard severity of NEGLIGIBLE for this airborne chemical hazard.

2) The effects associated with excessive exposure to carbon tetrachloride are listed in TG 230, Table Appendix C. Initial symptoms include irritation to eyes and skin; nausea and vomiting and other CNS effects. But based on the concentration found and the volatile nature of this chemical, you expect to see mild injury or temporary irritation amongst a small portion of the exposed group. As a result, you chose a Hazard severity of NEGLIGIBLE for this airborne chemical hazard.

Step 2.2. Hazard Probability Evaluation

(A) BC Raptor

Soil: Only ethyl benzene was identified as a potential health threat in soil. It was detected only in the locations where residual material from the fire remained. You notice that this is the area where all maintenance work will be performed. You decide that in order establish a risk level; you will select the most exposed soldier. In this case, it is the DS maintenance personnel because you expect them to have intimate, prolonged contact with the soil for the entire duration (working in an unimproved motor pool and they get a shower every three days).

You and the surgeon identify that the DS maintenance section is mission critical for the mission at this location, and that most if not all personnel will be exposed. However, you estimate that only 20 – 50 percent (Hazard Probability Ranking Chart in Table F-3) of the unit will contact soil at levels above the TG 230 guideline of 230 mg/kg. In addition, ethyl benzene is a volatile chemical, and should not be present for the entire year at this concentration.

As a result, the hazard probability for chemicals in soil at BC Raptor is chosen to be OCCASIONAL. You suspect that this is an overestimate due to the volatility, but decide to retain this estimate in order to be conservative.

Water: Mercury in water was identified as a potential health threat. Because this is the sole water source, all soldiers will drink from this water every day. As a result, the hazard probability was chosen to be FREQUENT. Though you note that this is a single sample, and may not adequately characterize the water supply.

Air: Benzene in air was identified as a potential health threat. Because this is an ambient measurement, the hazard probability was chosen to be FREQUENT. Though you note that this is a single sample, and may not adequately characterize the ambient conditions.

(B) BC Wolverine

Soil: No health threats were identified in the soil at this location

Water: The water supply was not tested.

Air: Mercury and carbon tetrachloride in air was identified as a potential health threat. Because these were ambient measurements, the hazard probability was chosen to be FREQUENT. Of course, these were taken as a single sample, and may not adequately characterize the ambient conditions.

Step 2.3. Risk Characterization

Tables 7-D and 7-E present the risk characterization summaries for each BC.

2.3.1. Risk Estimate

Based on the assessment of severity and probability of chemical hazards in various media at each site, you consider the FM 100-14 Operational Risk Management matrix in Table F-4 and conclude that the overall risks at both sites are similar –both are ranked MODERATE.

2.3.2. Confidence Level

(A) BC Raptor

The overall Moderate risk level associated with BC Raptor is driven by the benzene levels in the air and water in that area. However, the confidence in this risk estimate is LOW. This is primarily due to the lack of representative concentration data. Both the benzene and mercury concentrations were evaluated using single measurements, which may not be representative of the ambient concentrations of these chemicals. Exposure data is limited as well. The risk assessment is based on an arbitrary decision to use maintenance personnel as the most exposed person. This assumption will necessarily make the risk level an over conservative estimate of the risk to the rest of the personnel at this site.

(B) BC Wolverine

The risk level associated with BC Wolverine is also considered Moderate due to the mercury and carbon tetrachloride concentrations in air. This risk level assumes that the water selected for use at this site will not be a health threat for this location. The confidence in the overall risk level is considered LOW, however, mainly because of the lack of representative data. Both airborne chemical concentrations were evaluated using single measurements take over the space of 1 hour, which may not be representative of the ambient concentrations of these chemicals.

2.3.3. Threat Category

Based on these assessments, you believe that the environmental conditions at both sites may be HEALTH THREATS but should not be considered medical threats.

3. DEVELOP AND COMPARE CONTROLS FOR COA DEVELOPMENT

You present the risk levels above to the J3. Based on the BC risk assessment, you have estimated that the chemical hazards present at the two sites present a similar degree of risk (Moderate), and that you can only estimate this with a Low degree of confidence. However, you give slight preference to the use of BC Wolverine due to two factors. First, there is only one exposure pathway (inhalation) of concern at this site – soil samples suggest that soil contamination is not a health threat; and a bottled water supply negates concerns about this source. Second, the two contaminants present in the air do exceed MEGs, however, carbon tetrachloride (a B2 carcinogen) just barely exceeds the long-term Air-MEG and is substantially below its associated short-term exposure MEGs. Mercury more significantly exceeds the long-term MEG – but you notice there are no short-term MEGs for this compound, suggesting perhaps it is not a critical acute hazard. Though only one chemical was detected in the air at BC Raptor, you have hazards of concern in both water and soil as well. Even though soil and water pathways could be somewhat controlled, the benzene from the air is of particular concern. It is a Class A (known human) carcinogen and you note that not only does the sample level exceed the 1-year MEG, it is right at the 14-day MEG.

Step 3.1. Hazard Controls

Selection of the BC location in this case may be driven by other factors (such as logistical benefits, etc) since chemical hazards at both sites are of similar severity and probability. If BC Raptor is selected,

specific controls can be instituted to prevent/minimize exposures to chemicals in soil (educate personnel on minimizing contact (using clothing/gloves as barriers) and cleaning more frequently) and drinking water (such as obtain bottled water source). The airborne hazards that are present at either site are going to be difficult to minimize, so exposures will need to be documented. Continued monitoring of the ambient air situation will provide further information that could be used to control the risk to personnel at either site. In addition, source investigation may identify where these chemicals are coming from, and if concentrations remain at these levels or increase, active measures to control it could be implemented depending on the situation.

Step 3.2. Residual Risk

Even if soil and water hazards are eliminated from BC Raptor, the airborne hazard will still present a Moderate Risk. Likewise, there are no viable controls to reduce the Moderate Risk present at BC Wolverine.

Step 3.3. Actions to Increase Confidence in Risk Estimate

The major uncertainty in the risk estimate at both locations is the lack of data. Further actions should include more representative sampling in order to characterize the temporal aspects of the exposures. In addition, some investigation of the sources of the air pollution should be performed. The results of these investigations may be used to manage or eliminate the exposures (stop mercury emissions around wolverine) if the political/strategic situation allows.

TABLE 7-D. BASE CAMP RAPTOR RISK ASSESSMENT SUMMARY AND RECOMMENDED CONTROLS

CHEMICAL HAZARD	HAZARD RANKING			OPERATIONAL RISK ESTIMATE		PREDICTED HEALTH OUTCOME		CONTROLS & NOTES
	HAZARD TYPE	HAZARD PROBABILITY	HAZARD SEVERITY	RISK LEVEL	CONFIDENCE	DURING DEPLOYMENT	AFTER DEPLOYMENT	
Ethyl Benzene in Soil	Health Threat	Occasional	Negligible	Low	Medium	Symptoms: lightheadedness, headaches; dizziness; fatigue Incidence: <10%	Symptoms: uncertain Incidence:	Inform personnel to minimize contact/use of clothing/gloves; Increase allotted shower frequency
Mercury in Water	Health Threat	Frequent	Negligible	Moderate	Low	Symptoms: fatigue, tremors, loss of motor skills/visual acuity/higher mental function; weakness memory loss Incidence: <10%	Symptoms: Liver and kidney damage; memory loss Incidence: <10%	Alternate source of drinking water such as bottled water
Benzene in Air	Health Threat	Frequent	Negligible	Moderate	Low	Symptoms: Irritation of eyes, skin, nose, respiratory system; giddiness; headache, nausea, staggered gait; fatigue, anorexia, lassitude (weakness, exhaustion); dermatitis; Incidence: <10%	Symptoms: bone marrow depression, leukemia; cancer. Incidence: <10%	Continuous monitoring/ alternate site; exposures difficult to minimize – known (A) carcinogen; document exposures in personal records
Overall Threat	**Health Threat**	**Frequent**	**Negligible**	**Moderate**	**Low**			**Consider alt. site**

TABLE 7-E: BASE CAMP WOLVERINE RISK ASSESSMENT SUMMARY AND RECOMMENDED CONTROLS

CHEMICAL HAZARD	HAZARD RANKING			OPERATIONAL RISK ESTIMATE		PREDICTED HEALTH OUTCOME		CONTROLS & NOTES
	HAZARD TYPE	HAZARD PROBABILITY	HAZARD SEVERITY	RISK LEVEL	CONFIDENCE	DURING DEPLOYMENT	AFTER DEPLOYMENT	
Mercury and Carbon Tetrachloride in Air	Health Threat	Frequent	Negligible	Moderate	Low	Symptoms: Irritating to eyes, skin; cough, chest pain, dyspnea, bronchitis, pneumonitis; tremor, insomnia, irritability, indecision, drowsiness, dizziness headache, fatigue, weakness; stomatitis, salivation, GI distress, anorexia Incidence: <10%	Symptoms: liver, kidney injury; cancer (carbon tet) Incidence: <10%	Continuous monitoring/alternate site; exposures difficult to minimize – known carcinogen; document exposures in personal records
Overall Site Risk	**Health Threat**	**Frequent**	**Negligible**	**Moderate**	**Low**			**Preferred site**

APPENDIX G

DRINKING WATER PURIFICATION

The Performance of the Reverse Osmosis Water Purification Unit (ROWPU) with Respect to Removal of Soluble Contaminants from Source Waters

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WATER QUALITY INFORMATION PAPER NO. IP-31-014
WATER PURIFICATION BY REVERSE OSMOSIS

1. PURPOSE. This information paper provides guidance on the performance of the reverse osmosis water purification unit (ROWPU) with respect to removal of soluble contaminants from source waters. It is intended for the use of all preventive medicine and water point personnel, whether or not they have received formal instruction in membrane technology.

2. DISCUSSION.

a. Principles.

(1) Osmosis, for our purpose, is the process whereby water passes through a ?semipermeable? membrane, i.e., a membrane that obstructs the passage of salt or other material dissolved in the water. The direction of water passage is from the dilute solution side of the membrane to the concentrated side. For example, if a living cell is emersed in distilled water, the cell swells - sometimes to the bursting point - as water flows in through the cell membrane. If, on the other hand, the same cell is emersed in a saturated salt solution, water flows out and the cell is dehydrated, which is how road salt kills vegetation.

(2) Applying pressure to the concentrated solution side of a membrane reverses this osmotic process. This process allows us to construct a device to extract pure - or nearly pure - water from solutions of salt and other dissolved materials in a manner analogous to distillation, except that pressure provides the driving force rather than temperature. The ROWPU is such a device.

b. Removal of Simple Salts.

(1) It is important to understand that the original 600 gph ROWPU was designed to produce potable water from seawater or brackish water, i.e., to remove sea salts, principally sodium chloride or common salt. Other significant seawater constituents include salts of magnesium, calcium and potassium, as well as salts of bromine, sulfur (in the form of sulfate) and carbon (in the form of carbonate and bicarbonate). The product water from the ROWPU has 98- 99 percent of the sodium chloride removed (?rejected?) and at least that much of the other sea salts. Ordinary seawater contains about 3.5 percent (35,000 ppm) sea salts, so the product water should contain 350-700 ppm dissolved salts. This is more salt than in most municipal drinking water, but it is still well within the Army field water standard (1,000 mg/L). Note that if the seawater contains more than 3.5 percent salts, as is the case in the Persian Gulf, the ROWPU still removes just 98-99 percent. Thus, if the seawater contains 6 percent (60,000 ppm) salts, the product water will contain 600-1,200 ppm and may taste very slightly brackish. If, on the other hand, the ROWPU is used to purify fresh water, the product water may contain almost no salts and may taste ?flat.

(2) The membranes in the ROWPU are manufactured to remove sea salts. Any other chemical removal is a bonus, but such removal must be determined experimentally for the particular membrane, for each chemical, and for the conditions (temperature, pH, pressure) under which the equipment will be used. Some typical rejection data are presented in Table 1 for membranes similar to those used in the ROWPU. However, many new membranes, tailored for specific purposes, are being marketed. Some of these membranes may give significantly improved salt rejection and may provide greatly altered selectivity.

TABLE 1. REJECTION OF SALTS BY A TYPICAL RO MEMBRANE*

Salt	Rejection, percent
Sodium chloride	98
Magnesium chloride	98
Calcium chloride	99
Magnesium sulfate	99
Sodium bicarbonate	98
Sodium nitrate	93
Sodium fluoride**	98

* Filmtec[1], spiral wound, thin film composite polyamide. Data are provided by the manufacturer for pure solutions of each salt; they are not applicable to mixtures of salts.
**Fluoride rejection is pH dependent: about 75% at pH 5, 50% at pH 4, 30% at pH 3.5 and 0 % at pH <3.

c. Industrial Inorganic Chemicals.

(1) Most inorganic salts, including industrial chemicals, are removed from water by the ROWPU as well as sodium chloride. However, some inorganic salts are poorly removed (Table 2). Product water from a river contaminated with plating wastes will probably have 98-99 percent of nickel, copper and zinc removed and 96-98 percent of the cadmium, but perhaps only 90 percent or less of the chromium and cyanide. This may not seem like much of a difference, but note that a process which removes 90 percent of a pollutant leaves 10 times as much of the . pollutant in the product water as one that removes 99 percent. Removal efficiency is poor for mercury (33-78 percent) and arsenic (69-99 percent, depending on the chemical form). Removal efficiency is good for iron and manganese, but these metals may cause excessive fouling of the membranes.

[1] Filmtec is a registered trademark of FilmTec Corporation, Minneapolis, MN.

TABLE 2. REJECTION OF HEAVY METAL SALTS BY TYPICAL RO MEMBRANES

Salt	Rejection, percent
Nickel sulfate	99
Copper sulfate	99
Arsenic (+5) salts	99
Arsenic (+3) salts	69 and lower
Cadmium salts	99
Lead salts	97
Mercury salts	37-78
Chromium (+6) salts	97
Chromium (+3) salts	96

(2) Many of the common heavy metals found in polluted waters (lead, mercury, cadmium, arsenic, and chromium in particular) are highly toxic, and while the ROWPU may remove them well enough to meet health standards, it is still important to select the best raw water source available. This places increasing importance on the role of preventive medicine personnel in the process of water point site selection.

d. Organic Chemicals.

(1) Removal of organic materials may depend on size (i.e., molecular weight), structure and substitution (Table 3). Natural organic materials in water (lignans, tannins, fulvic substances) are essentially all removed, as are carbohydrates, proteins, and amino acids. Rejection of contaminants from industrial sources is highly variable. Removal efficiency is poor for low molecular weight alcohols such as methyl, ethyl, propyl and isopropyl alcohol, as well as for most low molecular weight solvents, including chlorinated solvents. In general, initial removal improves with increase in molecular weight, but this may be deceiving. Many organic contaminants that show good short-term removal in bench tests may ?leak? through the membrane in days or even hours. For example, removal of lindane may fall from an initial 97 percent to 85 percent after 24 hours. Weak organic acids of low molecular weight (acetic acid and its simple derivatives, propionic acid, butyric acid, phenol) are poorly removed.

TABLE 3. REJECTION OF SOME ORGANIC CHEMICALS BY TYPICAL RO MEMBRANES

Chemical	Rejection, percent
Aldehydes and Alcohols	
Formaldehyde	35
Methanol	25
Ethanol	70
Isopropanol	90
Sucrose (cane sugar)	99
Acids	
Acetic acid	60-90
Fluoroacetic acid*	98-99
Phenol	56-87
Benzoic acid	87-92
Solvents	
Trihalomethanes	50-80
Chloroethylenes	15-90
BTEX	15-50
Chlorobenzene	40-50
Herbicides	
Atrazine	96
Alachlor	98
Linuron	98

* Rodenticide; extremely toxic to humans

(2) Most organics will not cause acute health problems at the concentrations found even in polluted source water, although they may impart a taste so unpleasant that consumers will risk dehydration rather than drink it. However, some may present the risk of long-term health problems such as cancer. Because of the uncertainty in efficiency of rejection of industrial organics, it is again important to select the least contaminated source water for treatment. Surface waters immediately downstream from municipal or industrial outfalls should be avoided, in particular the outfall from a petrochemical complex

e. NBC Agents. Removing NBC agents from water by RO has received only limited investigation (Table 4). A single study indicates that the biotoxins, such as ricin, are reduced below detection limits by membranes similar to those in the ROWPU. Other studies indicate better than 99 percent removal for chemical agents and 95 percent or better removal for certain radioactive chemicals (nuclear agents). However, it is also known that radioactive materials eventually damage RO membranes. Furthermore, it may be assumed that membranes exposed to a constant challenge will eventually pass larger concentrations of chemical agents (but not most biotoxins).

TABLE 4. REJECTION OF NBC AGENTS BY REVERSE OSMOSIS

Agent	Rejection, percent
T-2	100
Microcystin	100
Ricin	100
Saxitoxin	100
GB	>99
VX	>99
BZ	>99
Hydrogen cyanide	<25*
^{131}I	>95
^{85}Sr	>99
^{134}Cs	>98

*pH $\leq$ 8.5

f. Parasites, Bacteria and Viruses. Reverse osmosis membranes have not, for the most part, been specifically tested for removal of bacteria, viruses, and parasites, such as *Giardia* or *Cryptosporidium* cysts. Based on size exclusion, it may safely be assumed that an undamaged membrane will remove virtually 100 percent of all microbiological organisms (although recent studies have indicated that virus removal efficacy may be subject to quality control limitations in membrane manufacture). Thus, the ROWPU is an effective barrier to water-borne pathogens. However, it is still important to avoid source water that may contain human or other animal wastes and to disinfect the ROWPU product water in order to prevent possible bacterial recontamination.

3. CONCLUSIONS. The ROWPU is a highly effective device for removing water pollutants and can provide an ample supply of assured safe drinking water if reasonable care is exercised in selection of the raw water source. It must be emphasized that the tabular data presented in this technical guide are for illustrative purposes only, and should not be used to estimate ROWPU product water quality except in the most general sense. Reverse osmosis performance depends, among other things, on the operating parameters, the choice and condition of the membrane, and the pH and temperature of the water. Knowledge of performance of the ROWPU with respect to individual source water constituents is still limited.

4. ADDITIONAL INFORMATION. Field preventive medicine personnel and others with specific health-related questions on treatment of water for both potable and nonpotable use are urged to contact the Water Supply Management Program, U.S. Army Center for Health Promotion and Preventive Medicine: phone (410) 436-3919, DSN 584-3919; Fax (410) 436-8104; email: wsmp@apgea.army.mil; home page: http://chppm-www.apgea.mil/dwater.

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ADDITIONAL INFORMATION, GUIDANCE, RESOURCES

MILITARY DOCTRINE AND POLICY

?? http://www.usapa.army.mil/pdffiles/l1_011.pdf : ***DA Policy Letter on Force Health Protection-Occupational and Environmental Health Hazards*** *- published by the US Army Publications Agency (June 2001)*

?? **http://www.adtdl.army.mil/atdls.htm: GEN Reimer's Training and Doctrine Digital Library** *- great way to obtain ARs, Pams, FMs, etc. Refer to this site to look up FMs /related doctrine regarding NBC topics and preventive medicine*.

?? **http://www.dtic.mil/doctrine/index.html: source library for JOINT doctrine**

USACHPPM TECHNICAL GUIDANCE AND DEPLOYMENT RISK ASSESSMENTS

?? **http://chppm-www.apgea.army.mil/desp/pages/despinfo.htm: USACHPPM Deployment Environmental Surveillance Programs website** has *information regarding field equipment, **deployment sampling kits**, ongoing **past/ongoing deployment OEH surveillance** and risk assessment projects in **Kosovo, Bosnia**, and related to the **Gulf War**. This also has/downloadable versions of various USACHPPM TG:*

- **TG 248** ***Guide for Deployed Preventive Medicine Personnel on Health Risk Management (2001)***
- **TG 230/RD 230** ***Chemical Exposure Guidelines for Deployed Military Personnel (2002)***
- **TG 236A**: ***Basic Radiological Dose Estimate - A Field Guide (2001)***
- **TG251** ***Environmental Health Field Sampling Guide for Deployments (Draft 2001)***

HAZARDOUS MATERIAL RESPONSE

?? **TICs/TIMs detector tube ordering information** http://instrumentdepot.com/tubes.htm

?? **Managing Hazardous Materials Incidents,** *US Agency for Toxic Substances and Disease Registry, Vol 1- for Emergency Medical Services, Vol 2 for Hospital Emergency Departments, and **Vol 3 is for the Medical Management Guidelines for Acute Chemical Exposures**.* http://aepo-xdv-www.epo.cdc.gov/wonder/prevguid/p0000018/p0000018.asp

?? **Pocket Guide to Chemical Hazards,** *US National Institute for Occupational Safety and Health, US Department of Health and Human Services.* http://www.cdc.gov/niosh/npg/pgdstart.html

?? **2001 Emergency Response Guidebook,** *North America (US DOT, Canada, Mexico)* http://hazmat.dot.gov/gydebook.htm

?? **Hazardous Materials Guide for First Responders** *, US Fire Adminstration - Federal Emergency Management Agency*. http://www.usfa.fema.gov/hazmat/

?? **Guide for the Selection of Chemical Agent and Toxic Industrial Material Detection Equipment for Emergency First Responders,** National Institute of Justice; Vol.1 general guide, Vol. 2 -detection equipment data sheets. http://www.ojp.usdoj.gov/nij/pubs-sum/184449.htm

CHEMICAL WARFARE AGENTS AND ASSOCIATED HEALTH GUIDELINES

?? **USACHPPM CWA and Associated Health Guidelines** *includes information and links to sites that provide information on basic chemical, physical and toxicological properties of CWA. Information on health related guidance and current environmental policy issues is also available.* **http://chppm-www.apgea.army.mil/hracp/pages/caw/home.htm**

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